

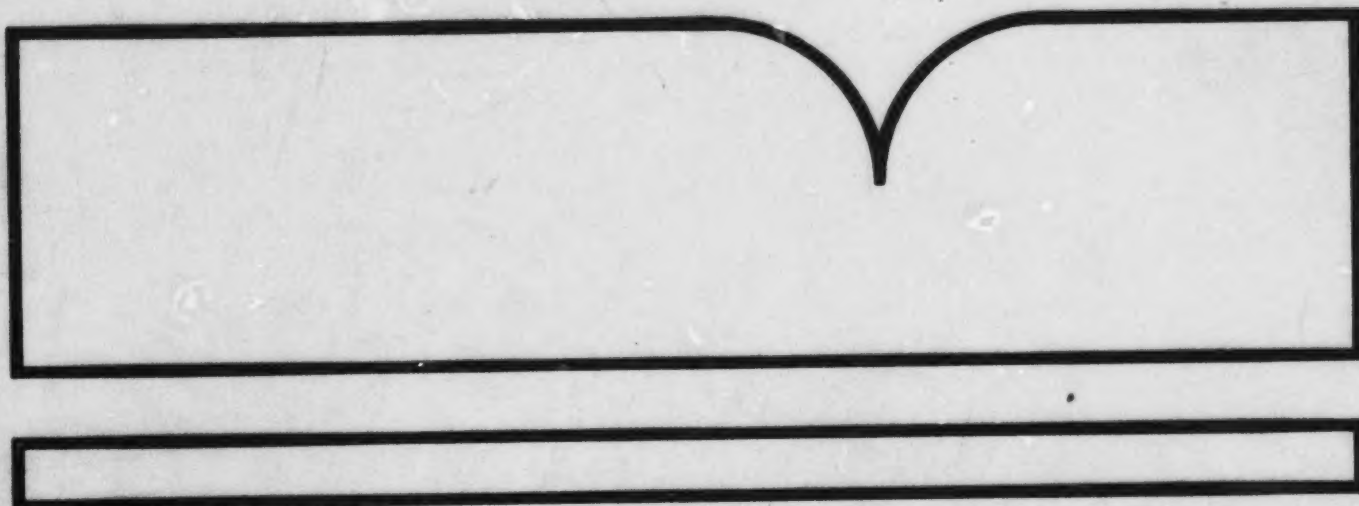
Analysis of the Economics of Water
Supply in the Washington Metropolitan Area

ACT Systems, Inc.
Winter Park, FL

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Jul 80



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ANALYSIS OF THE ECONOMICS
OF WATER SUPPLY IN THE
WASHINGTON METROPOLITAN AREA

by

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that first step in problem solution, and involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems: 1) to prevent, treat, and manage wastewater, solid and hazardous waste, and pollutant discharges from municipal and community sources; 2) to preserve and treat public drinking water supplies; and 3) to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is a product of that research and is a most vital communications link between the researcher and the user community.

This report discusses the economic tradeoffs involved in supplying water to the Washington Metropolitan Area and provides an example of how such research might be applied to other potentially water-short areas.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

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ABSTRACT

As a result of a controversy arising over available water supply in the Washington Metropolitan Area, the U.S. Environmental Protection Agency, administrator for Region III, requested that a cost analysis of the water supply system in the Washington, D.C. area be made. The analysis required a survey of the major water purveyors within the WMA which draw water from the Potomac River or have plans to do so in the near future. The utilities were visited to secure water supply cost information. In addition to the major water purveyors, selected customer utilities which receive all or part of their water from these purveyors were visited. All plans for future expansion of water supply facilities which include additional wells, reservoirs on the Potomac and its tributaries, reservoir interconnections, and possible wastewater reuse alternative plans were evaluated. The data included in this document provide an in-depth analysis of the water supply situation within the WMA, and represent a new approach in projecting water supply needs through the year 2050.

This report represents a joint effort between MERL in-house staff, and the ACT Systems, Inc. staff. The analysis and report writing aspects of this study were accomplished primarily by Drinking Water Research Division personnel, and the field data collection aspects of the study by ACT Systems, Inc. The data presented in this report represent the fulfillment of contract No. 68-03-2506 by ACT Systems, Inc. The appendices listed in the report were prepared by many individuals whose names are listed in conjunction with their contribution.

Results of the analysis show that the occurrence of a water shortage situation in the near future (20 years) is unlikely with proper operation of existing reservoirs. However, even with no increase in per capita water consumption, a significant risk of a severe water shortage is likely in the more distant future (over 25 years). Of all options considered, the one appearing to be most feasible (least costly) was the construction of more reservoirs on the Potomac.

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CONTENTS

	<u>Page</u>
Foreword.	iii
Abstract.	iv
Figures	vii
Tables	ix
Abbreviations and Symbols	x
Acknowledgment.	xi
1. Introduction	1
2. The Study Area	3
3. The Potomac River Basin	9
4. Institutions Supplying Water in the WMA	13
5. Current and Future Demand in WMA	19
Raw Water Demand	19
Demand for Revenue-Producing Water	21
Components of Demand	21
Growth in the WMA	27
6. Deficit Flow Analysis	41
Deficit Flow Analysis Results	44
Effect of the Bloomington Reservoir on Deficit.	53
Reservoirs and In-System Storage	54
Interconnections	54
Renovated Wastewater	54
Conservation	54
7. Analysis of Augmentation Options	60
Reservoir and Storage Solution.	60
Alternate Discharge Pattern	60
Renovated Wastewater.	66
Interconnections.	71
Economic Comparison	82
Conservation	82
8. Water Supply Utility Costs.	103
Washington Suburban Sanitary Commission	103
Cost Analysis	105
Systems Evaluation	105
Public Water System D.C.	108
Cost Analysis.	108
Systems Evaluation	108
Fairfax County Water Authority	115
Cost Analysis	115
Systems Evaluation	115

BEGIN
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EPA-287 (Cin.)
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CONTENTS (continued)

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		Page
	Rockville Water Utility	120
	Cost Analysis	120
	Systems Evaluation	120
	Arlington County Water Utility	120
	Cost Analysis.	125
	Systems Evaluation	125
	Falls Church Water Supply	125
	Cost Analysis.	125
	Systems Evaluation	125
	Leesburg Water Utility.	134
	Cost and System Analysis	134
	Comparative Cost Evaluation	134
9.	Reflections	143
	Individual Solutions	144
10.	Summary and Conclusions	146
References		149
Appendices		
A.	Potomac River Low Flow Allocation Agreement . . .	152
B.	Population and Water Demand Calculations by James A. Goodrich and Gregory D. Trygg, Drinking Water Research Division, MERL	163
C.	Analysis of Flows in the Potomac River by Stan Forsyth, James A. Goodrich and Gregory D. Trygg, Drinking Water Research Division, MERL . .	171
D.	Facility Solution Program by Daniel L. Guttman, Drinking Water Research Division, MERL	186
E.	Water Utilities Section by W. Kyle Adams and James I. Gillean, ACT Systems, Inc.	218
	Printout for WSSC	286
	Printout for Combined WAD and D.C. DES .	305
	Printout for Aqueduct Division of C.O.E.	324
	Printout for D.C. DES	343
	Printout for Rockville Water Utility . .	362
	Printout for Falls Church Water Supply .	381
	Printout for Arlington Co. Water Supply.	400
	Printout for Leesburg Water Utility. . .	419
	Printout for FCWA	438
F.	Flow Analysis for Potomac, Bull Run, Patuxent, and Deer Creek, by James A. Goodrich	457
G.	Comparative Cost Analysis, by Robert M. Clark . .	461

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vi

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FIGURES

<u>No.</u>		<u>Page</u>
1.	Major jurisdictions in WMA considered in study	4
2.	Hydrograph of 1966 Potomac River flow vs 1973 withdrawal.	5
3.	Hydrograph of 1930 Potomac River flow at Point of Rocks	7
4.	Hydrograph of 1966 and 1930 flows at Point of Rocks	8
5.	Potomac River Basin	10
6.	Metropolitan Washington D.C. treatment facilities	15
7.	Population in Metropolitan Washington by PAD (1970)	28
8.	Population in Metropolitan Washington by PAD (1995)	29
9.	Percent change in population by PAD in Metropolitan D.C.	30
10.	Total employment in Metropolitan Washington by PAD (1972)	31
11.	Total employment in Metropolitan Washington by PAD (1995)	32
12.	Percent change in employment in Metropolitan Washington by PAD	33
13.	Future water use under different alternatives	36
14.	Supply and demand relationships	39
15.	Deficit flow conditions for 1980, 2030, and 2050 demand versus 1966 river flow	42
16.	Deficit flow history based on 2050 estimated demand	45
17.	Frequency of yearly deficits	46
18.	Frequency of deficit periods	47
19.	Magnitude of yearly deficits (1930 river flow).	48
20.	Magnitude of yearly deficits (1966 river flow).	49
21.	Magnitude of yearly deficits (1932 river flow).	50
22.	Location of deficits in time (2030 demand).	51
23.	Location of deficits in time (2050 demand).	52
24.	Deficit analysis with Bloomington Reservoir on line (2050 demand)	55
25.	Magnitude of yearly deficits with Bloomington Reservoir on line (1930 river flow)	56
26.	Magnitude of yearly deficits with Bloomington Reservoir on line (1966 river flow)	57
27.	Magnitude of yearly deficits with Bloomington Reservoir on line (1932 river flow)	58
28.	Reservoir sites within the WMA river system	63
29.	Reservoir solution schedule of development	65
30.	Effect of Bloomington Reservoir release (optimal) pattern	67
31.	Renovated wastewater facilities within WMA river system	69
32.	Renovated wastewater solution schedule of development (based on 1930 river flow conditions)	72
33.	Renovated wastewater solution schedule of development (based on 1966 river flow conditions)	73
34.	Renovated wastewater solution schedule of development (based on 1932 river flow conditions)	74
35.	Interconnect concept for WMA river system	75

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AREA

FIGURES (continued)

No.		Page
36.	Interconnect solution schedule of development (based on 1930 river flow conditions)	78
37.	Interconnect solution schedule of development (based on 1966 river flow conditions)	79
38.	Interconnect solution schedule of development (based on 1932 river flow conditions)	80
39.	Cumulative time-investment curve (based on 1930 flow conditions).	83
40.	Time-investment curve annual cost (based on 1930 river flow).	84
41.	Cumulative time-investment curve (based on 1966 river flow).	85
42.	Time-investment curve annual cost (based on 1966 river flow).	86
43.	Cumulative time-investment curve (based on 1932 river flow).	87
44.	Time-investment curve annual cost (based on 1932 river flow).	88
45.	Optimal release pattern for Bloomington (2030 demand) without conservation	89
46.	Optimal release pattern for Bloomington (2030 demand) with conservation	90
47.	Optimal release pattern for Bloomington (2050 demand) without conservation	91
48.	Optimal release pattern for Bloomington (2050 demand) with conservation	92
49.	Magnitude of yearly deficits with Bloomington Reservoir on line with conservation (based on 1930 river flow)	93
50.	Magnitude of yearly deficits with Bloomington Reservoir on line with conservation (based on 1966 river flow)	94
51.	Deficits with conservation (2030 demand)	95
52.	Deficits with conservation (2050 demand)	96
53.	Cost of conservation (Washington, D.C. MWA)	102
54.	WMA water supply utilities service area map	104
55.	WSSC water utility water flow: treated water versus RPW	106
56.	WSSC facilities map	109
57.	WSSC allocation of capital and operating expenses	110
58.	D.C. Public water system: treated water versus RPW	112
59.	D.C. Public water system facilities map	113
60.	D.C. allocation of capital and operating expenses	114
61.	Fairfax County Water Authority: treated water versus RPW	116
62.	Fairfax County Water Authority facilities map	118
63.	Fairfax allocation of capital and operating expenses	119
64.	Rockville Water Utility: treated water versus RPW	121
65.	Rockville Water Utility facilities map	123
66.	Rockville allocation of capital and operating expenses	124
67.	Arlington County Water Utility: treated water versus RPW	126
68.	Arlington County Water Utility facilities map	128
69.	Arlington allocation of capital and operating expenses	129
70.	Falls Church Water Supply: treated water versus RPW	130
71.	Falls Church Water Supply facilities map	132
72.	Falls Church allocation of capital and operating expenses	133
73.	Leesburg Water Utility: treated water versus RPW	135
74.	Leesburg Water Utility facilities map	137
75.	Leesburg allocation of capital and operating expenses	138
76.	Annual cost versus capacity of supply augmentation options	142

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TABLES

<u>No.</u>		<u>Page</u>
1.	Average, maximum, and minimum reported monthly flows for the Potomac River at Point of Rocks, Maryland	12
2.	Yearly raw water demand by utility	14
3.	Water consumption in WMA (1976)	17
4.	Average raw water pumped by major purveyors (1976).	20
5.	Demand ratios for WMA	22
6.	Revenue producing water by major purveyor	23
7.	Ratio of raw water to revenue-producing water for major purveyors	24
8.	Numbers and types of customers for WSSC (1977).	25
9.	Residential and employment demand for major WMA utilities (1976).	26
10.	Per capita water usage scenario	35
11.	Projected annual requirements for revenue-producing water	37
12.	WMA water demand (MGD) by category.	38
13.	Monthly demand without conservation for 1980 and 2050	43
14.	Potomac flow augmentation	53
15.	Projected deficits	61
16.	Peak deficit	62
17.	Reservoir costs	64
18.	Effect of alternate release date	66
19.	Renovated wastewater	70
20.	Supply MGD (unregulated flows 1930)	77
21.	Interconnection costs	81
22.	Costs per family for retrofitted low-flow devices	98
23.	Percent using water conserving devices (residential).	99
24.	Percent using water conserving devices (other users).	100
25.	Total cost of water conservation	101
26.	Summary of operating and capital expenditures - WSSC	107
27.	Summary of operating and capital expenditures - D.C.	111
28.	Summary of operating and capital expenditures - Fairfax	117
29.	Summary of operating and capital expenditures - Rockville	122
30.	Summary of operating and capital expenditures - Arlington	127
31.	Summary of operating and capital expenditures - Falls Church.	131
32.	Summary of operating and capital expenditures - Leesburg	136
33.	Magnitude of yearly deficits	139
34.	Washington Area utility cost summary (1930 river flow).	140

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ABBREVIATIONS AND SYMBOLS

cfs	-- cubic feet per second
ENR	-- Engineering News Record
FCWA	-- Fairfax County Water Authority
Maximum day/ maximum hour	-- maximum day flow for the year in MGD/maximum hour flow for the year in MGD
MGD	-- million gallons per day
mil gal	-- million gallons
NEWS	-- Northeastern Water Supply Study
PAD	-- planning analysis district
Retail service area	-- area in which water is retailed by the utility
RPW	-- revenue-producing water. The water measured as metered consumption and paid for by wholesale and retail customers in the service area
RW	-- raw water
RWW	-- renovated wastewater
SMSA	-- standard metropolitan statistical area
WAD	-- Washington Aqueduct Division
WMA	-- Washington Metropolitan Area
WSSC	-- Washington Suburban Sanitary Commission

METRIC CONVERSION TABLE

English Units

Metric Equivalents

1 foot	0.305 meters
1 mile	1.61 kilometers
1 sq mi	2.59 sq kilometers
1 mil gal	3.79 thou cu meters
1 \$/mil gal	0.26 \$/thou cu meters

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Mr. H. W. Smith, Director, Dept. of Public Utilities, City of Falls Church.

Mr. Bill Jefferies, Director of Public Utilities, Arlington County.

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SECTION 1

INTRODUCTION

"If we took all of the studies that have been done on the Washington Area water supply problem and threw them into the Potomac River, we'd have a dam."(1) This quoted statement, made by J. J. Corbalis, Jr., Director of the Fairfax County Water Authority (FCWA), describes the frustration of many individuals involved in water supply planning in the Washington, D.C. Metropolitan Area (WMA). It is hoped that this report will contribute something more than simply adding to the paper work "dam" of reports already published that have attempted to analyze the WMA water problem.

Concern over water supply issues is longstanding and involves all levels of government, private interest groups, and individual citizens. Interest in these issues peaked on August 20, 1976, when Russell Train, former administrator of the U.S. Environmental Protection Agency (EPA), rejected a construction grant application submitted by the State of Maryland for a renovated waste water (RWW) facility.(2) The facility was to have been constructed in Montgomery County, Maryland, in the vicinity of Dickerson. The State of Maryland promptly filed suit against EPA in an attempt to recover damages which it allegedly incurred as a result of EPA's adverse decision.

One of the arguments supporting the proposed RWW facility was that it would help augment what is considered to be a limited water supply in the Potomac River during low flow periods. Therefore, the State of Maryland claimed certain water supply "benefits" from the construction of the plant.(3) Based on their analysis, EPA economists disputed the claims made by the State of Maryland and disallowed the claimed benefits. (4)

Many factors were considered by EPA in arriving at their final decision, but during the course of the analysis, it became clear that little definitive information was available concerning water supply costs in the WMA. Because of this information gap, Daniel J. Snyder III, former U.S. EPA Administrator for Region III, requested that the EPA laboratory in Cincinnati undertake a water supply cost study.(5) The data resulting from the study would provide background information on water supply costs and would be useful in future evaluation of water supply augmentation strategies for the WMA.

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The results of the data collection and analysis effort are contained in this report. The study has three major components: a collection of baseline cost data from the utilities that are withdrawing or planning

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to withdraw water from the Potomac River: an analysis of various water supply augmentation possibilities under a series of different projected demand conditions; and a series of scenarios in which different water supply strategies were evaluated as to their cost impact on individual utilities.

This report and associated analysis is the result of a joint effort between the Drinking Water Research Division staff and the ACT Systems, Incorporated staff. Report writing and analysis was primarily the result of in-house effort, while the data collection aspects of the study were accomplished primarily by ACT Systems staff. The beneficial contribution of individuals who were not directly involved in the completion of the final report is shown by their authorship of the report's appendices.

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SECTION 2

THE STUDY AREA

The Metropolitan Washington Area (WMA) is defined as shown in Figure 1, including: the counties of Loudoun, Prince William, Fairfax and Arlington and the independent cities of Alexandria and Manassas Park in Virginia; the counties of Montgomery, Prince Georges, and Charles in Maryland; and the District of Columbia. Within this area, there are 25 independent water supply systems ranging in size from less than 1 MGD capacity to several hundred MGD capacity. Of these 25, there are three large water supply facilities which furnish about 95 percent of the total water treatment capacity of the WMA. They are: the Washington Aqueduct Division (WAD), operated by the Army Corps of Engineers, which serves the District of Columbia, Arlington, Falls Church, and part of Fairfax County; the Washington Suburban Sanitary Commission (WSSC), serving Montgomery and Prince Georges Counties; and the Fairfax County Water Authority (FCWA) serving Fairfax County, the City of Alexandria, and part of Price William County. (6)

Because over 95 percent of the water is supplied by a few utilities, it was decided to limit this study to the three major utilities identified above, plus the following: Rockville (draws water from the Potomac); Leesburg (plans to draw water from the Potomac), D.C. Department of Environmental Services (obtains water from WAD); Arlington (buys water from WAD); and Falls Church (buys water from WAD). This group includes all suppliers that presently draw water or that have requested water from the Potomac. All projections for future water requirements are based on the entire WMA.

The problem of assuring an adequate potable water supply to the WMA has been a subject of intense debate for at least 15 years, and of concern for many more.(7) The crucial issue at this time is the growing reliance on the Potomac River as a source of drinking water for the WMA. Under most flow conditions, the volume of water in the Potomac River far exceeds present or projected needs. However, because the river flow is unregulated and is subject to extreme fluctuations over short time periods, there is concern that water supply shortages may result from the simultaneous occurrence of a maximum water demand period and a low flow period.

Figure 2 illustrates the problems of depending on the Potomac River for water supply. The figure shows the 1966 flow of the Potomac, using the Point of Rocks river gauge versus 1973 total water withdrawals and the projected 2030 monthly demand.(8) The Point-of-Rocks gauge is the closest

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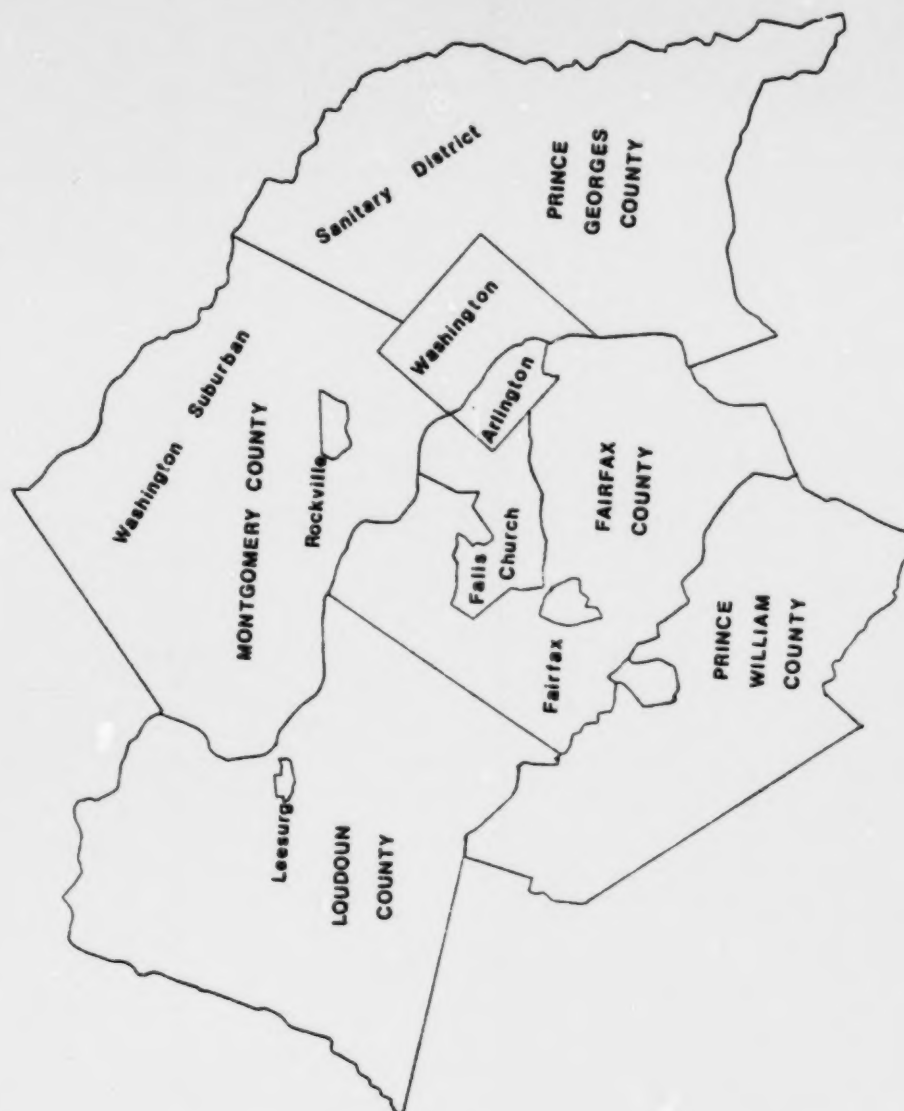


Figure 1. Major jurisdictions in Washington Metropolitan Area considered in study.

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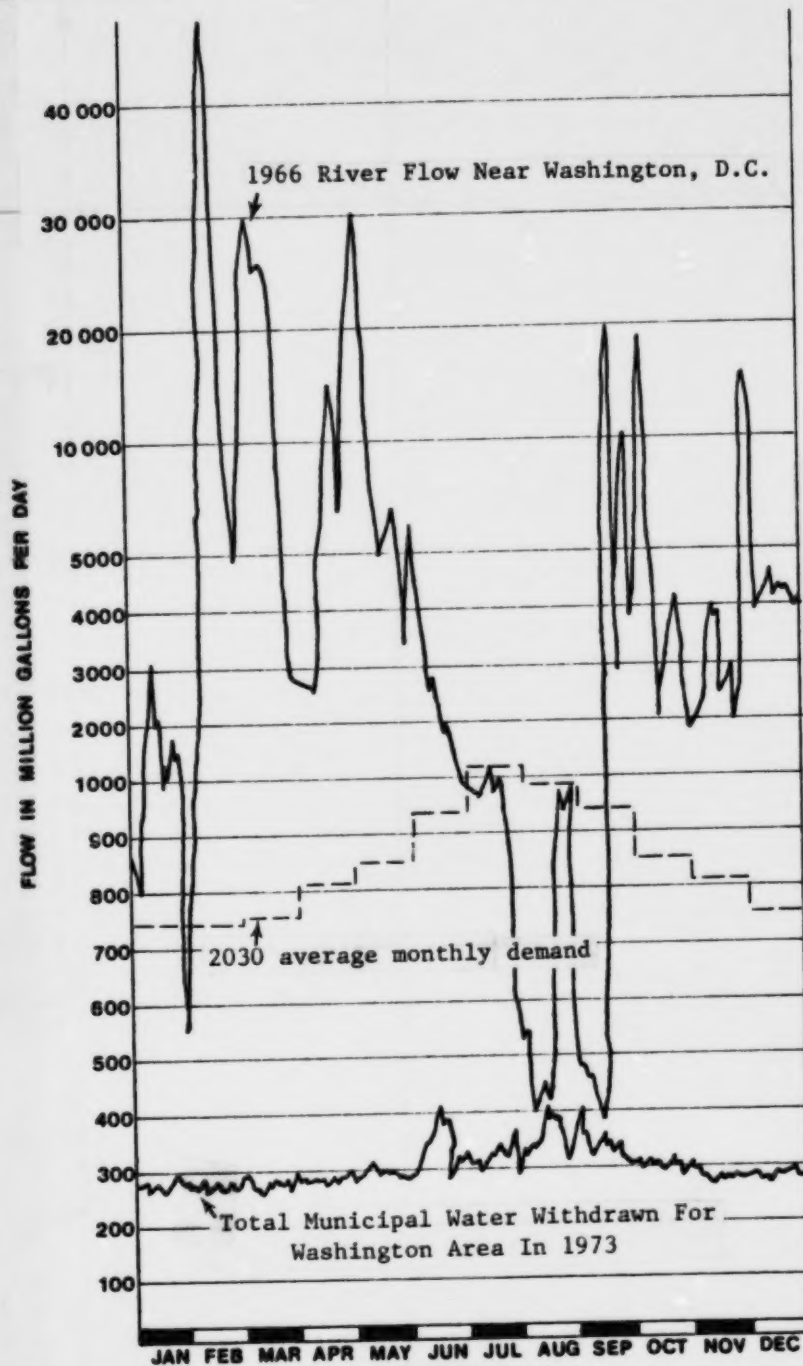


Figure 2. Hydrograph of 1966 Potomac flow near Washington D.C. versus 1973 municipal withdrawal and projected 2030 average monthly demand.

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reliable stream-flow measuring device on the Potomac upstream of the WMA water supply intakes. The 1966 flow is the lowest flow of record. As can be seen, the peak demand for water in 1973 was actually greater than the low flow of the river in 1966. The projected 2030 monthly demand far exceeds the 1966 river flow. From this comparison, it is apparent that if demand for Potomac water increases, future shortages could occur.

The low flow of 1966 was of relatively short duration, lasting approximately 2 months. Another low flow occurred in 1930 for 5 months, with a minimum flow only slightly higher than the 1966 minimum flow. Figure 3, a hydrograph of the Potomac flow at Point of Rocks in the year 1930, shows that the flow dropped to approximately 500 million gallons per day (MGD) in July and stayed close to that level until December.(9)

Figure 4 shows the 1930 and 1966 flows plotted on one graph. As can be seen, the two low flow conditions have similar initial patterns, but the 1966 flow dropped below the 1930 flow and then increased to normal levels after 2 months, while the 1930 flow continued at a relatively low level.

Two of the three major water suppliers in the WMA - the Washington Suburban Sanitary Commission and the Washington Aqueduct Division of the U.S. Army Corps of Engineers (COE) - rely on the Potomac River as a major source of drinking water. The Washington Suburban Sanitary Commission (WSSC), which supplies Montgomery and Prince Georges Counties in Maryland, obtains slightly over 60 percent of its water from the river, and the remaining 40 percent from wells and reservoirs on the Patuxent River. The Washington Aqueduct Division (WAD) of the U.S. Army Corps of Engineers, which supplies the District of Columbia, the City of Falls Church, and Arlington County, Virginia, obtains all its water from the Potomac. A third major regional supplier - the Fairfax County Water Authority (FCWA) now uses the Occoquan Reservoir as its major source, but has recently been granted a permit to build a Potomac River intake. Therefore, all three water purveyors view the Potomac River as a mean of meeting current or future demands for water in their service areas.(10)

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POINT OF ROCKS, MARYLAND

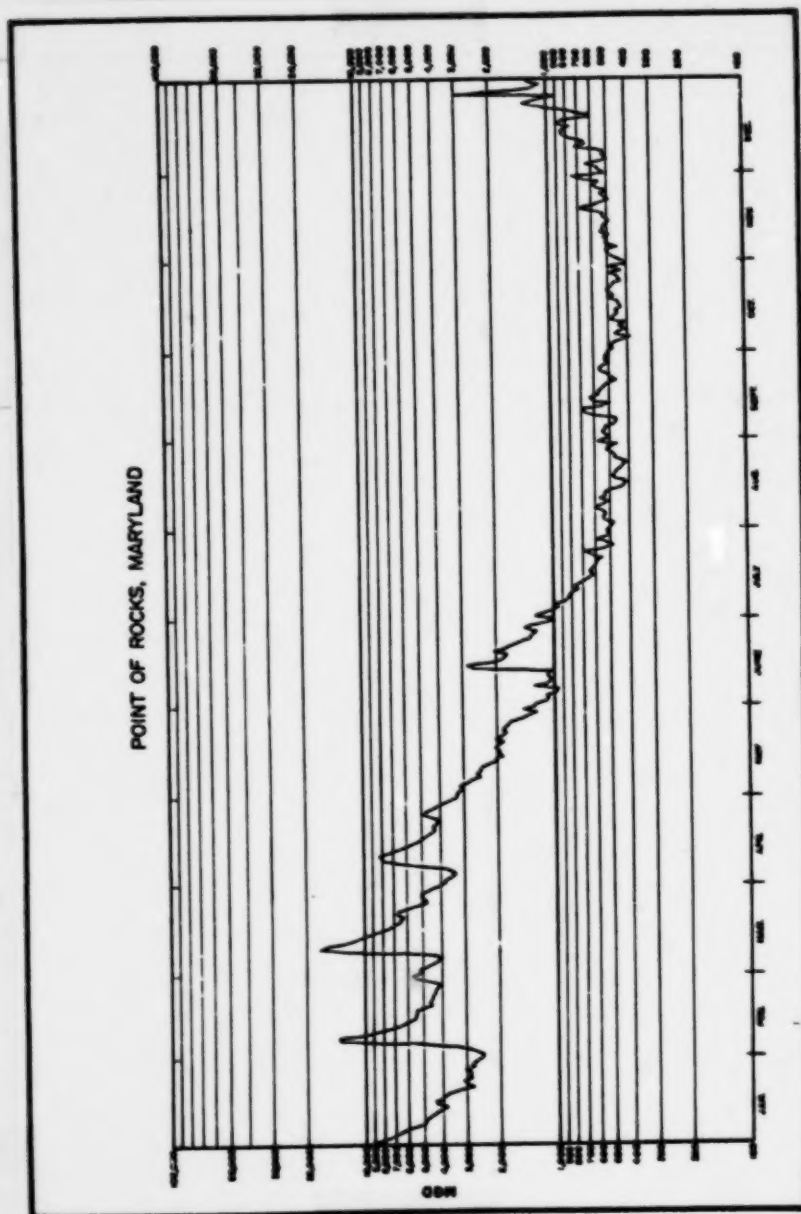


Figure 3. Hydrograph of 1930 Potomac River Flow at Point Of Rocks, Maryland.

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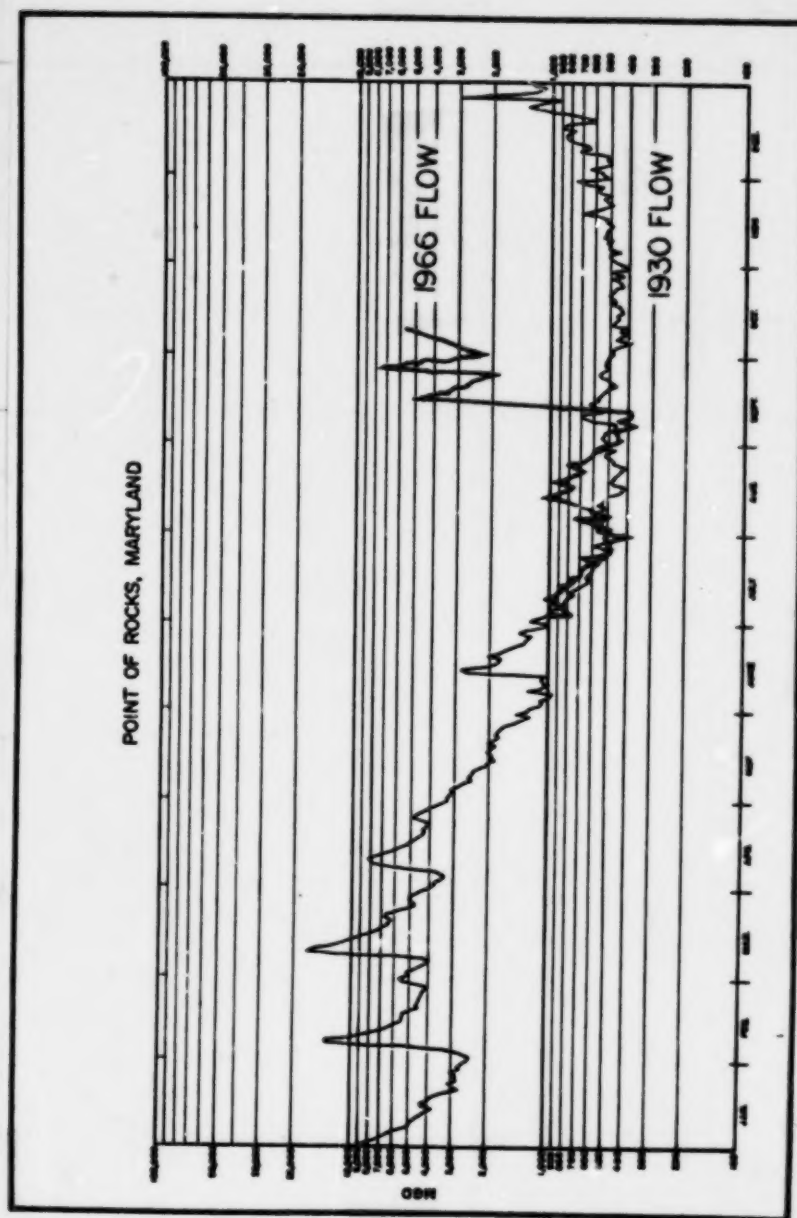


Figure 4. Hydrographs of 1966 and 1930 flows at Point of Rocks, Maryland.

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SECTION 3

THE POTOMAC RIVER BASIN

The Potomac River system drains an area of 14,669 square miles: 5,720 square miles in Virginia, 3,820 square miles in Maryland, 3,490 square miles in West Virginia, 1,570 square miles in Pennsylvania, and 69 square miles in the District of Columbia. The main stem is approximately 283 miles long from its mouth to the confluence of the North and South Branches below Cumberland, Maryland. The North Branch, which is considered to be the origin of the river, continues for an additional 100 miles. Both the North and South Branches drain about 3,000 square miles of heavily forested Appalachian Plateau. The largest tributary, the Shenandoah River, drains an additional 3,000 square miles of broad and fertile valley farmlands bordered by forested ridges.(11)

The Potomac River is tidal for approximately 115 miles from its mouth at the Chesapeake Bay to just above Washington, D.C., where it crosses the fall line at the Little Falls of the Potomac. The river is navigable for 108 miles, with a maintained channel depth of 24 feet in the tidal reaches. The width at the mouth of the river at Point Lookout, Maryland, is 11.3 miles, while from Great Falls to Harper's Ferry the width averages 1,300 feet. During periods of low flow, this reach of the river is approximately 6 feet deep. In the estuarine portion of the river, depths are highly variable, with a maximum of 107 feet at Morgantown, Maryland. Depths of 40 to 60 feet are common. The estuarine portion of the Potomac below the fall line is dominated by the reversal of flow caused by tides and the associated change in water levels. These two factors, as well as the intrusion of salt water in the estuary, are modified by the level of discharge from the freshwater portion of the river.

The U.S. Geological Survey maintains many gauging stations on the nontidal portion of the Potomac River and its tributaries. The gauges immediately applicable to this study are at Point of Rocks, Maryland, and the station just above Little Falls. Additional gauges used in the analysis are those on Seneca Creek, Difficult Run, the Monocacy River, and others shown in Figure 5. Reliable data have been generated at Point of Rocks since 1895 and at Little Falls since 1930, but data from the other gauges are variable. The Point of Rocks gauge measures flow prior to any Washington area water withdrawals, while the Little Falls gauge is located below the existing and proposed intakes. The difference between the two, after correction for diversion, represents the contribution of local tributaries and direct runoff.(12)

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In this study, the Point of Rocks gauge was used as the basis for

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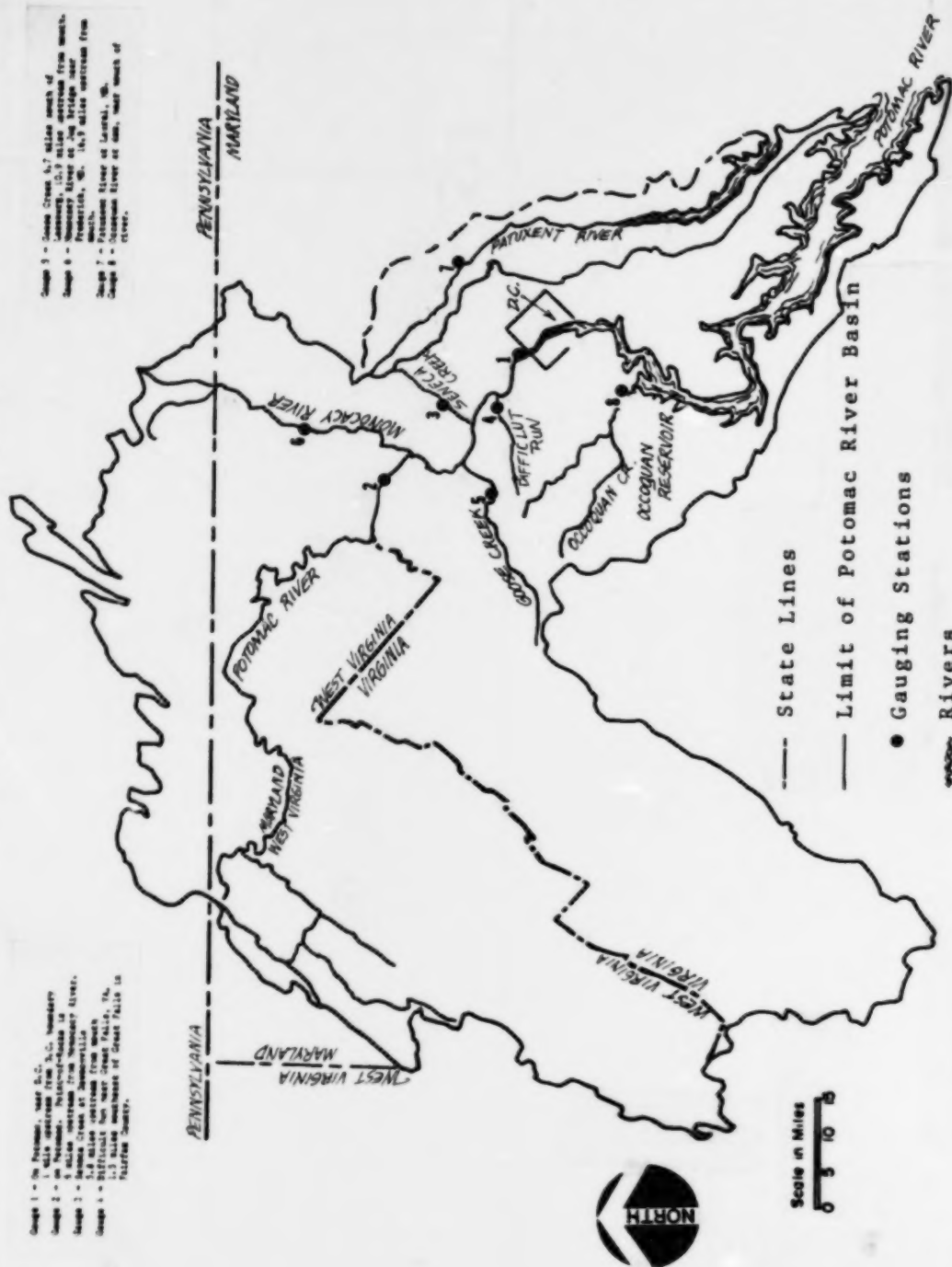


Figure 5. Potomac River Basin and gauging stations.

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Scale 1 - On Potomac River, near D.C.
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calculating available water supply in the WMA for the following reasons:(13)

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1. It has a long record of measurement, including the 1930 drought, which was critical to the region.
2. It is a very stable gauge, giving accurate measurements at all stages.
3. It measures most of the water entering the MWA from the Potomac and its tributaries.
4. It does not require the adjustment of flow records to account for water supply withdrawal.

Data from the Point of Rocks gauge typify flow conditions in the Potomac near the WMA. Table 1 summarizes the maximum and minimum flows for the period of record at Point of Rocks.(14) As shown in Table 1, minimum monthly average flows have ranged from 706 cubic feet per second (cfs) (456 MGD) in October 1931 to 5,400 cfs (3,490 MGD) in March 1931. Low flows have been recorded in all months from July through December. The standard deviation of the monthly flows indicates that the river flows are also extremely variable.

To estimate available water supply just above the WMA area, flows from all of the tributaries were calculated, and a relationship was developed that provided total available supply above the gauges as a function of flow at the Point of Rocks gauge. This relationship will be discussed in more detail later in the report.

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TABLE 1. AVERAGE, MAXIMUM, AND MINIMUM REPORTED MONTHLY FLOWS FOR THE POTOMAC RIVER AT
POINT OF ROCKS, MARYLAND (based on period October 1, 1895 to March 31, 1976)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Average monthly												
flow cfs	4,820	5,048	8,210	11,280	14,460	19,260	16,120	11,930	8,225	4,516	4,316	3,510
MCD	3,115	3,263	5,306	7,290	9,346	12,448	10,419	7,711	5,316	2,919	2,790	2,269
Standard deviation												
cfs	5,634	4,060	6,344	6,555	7,860	10,530	8,270	7,080	6,138	2,914	3,879	3,151
MCD	3,641	2,624	4,100	4,237	5,080	6,806	5,345	4,576	3,967	1,883	2,507	2,037
Maximum monthly												
flow cfs	37,030	18,770	32,610	31,350	42,660	68,360	39,840	41,970	40,400	16,000	23,580	17,820
MCD	23,933	12,131	21,076	20,226	27,572	44,103	25,749	27,126	26,111	10,341	15,240	11,517
Water year	1943	1973	1973	1937	1897	1936	1918	1924	1972	1949	1955	1975
Minimum monthly												
flow cfs	706	840	1,253	1,896	2,661	5,400	4,368	3,276	1,932	1,056	771	834
MCD	456	543	810	1,225	1,720	3,490	2,818	2,117	1,246	683	498	539
Water year	1931	1931	1966	1966	1934	1931	1915	1930	1969	1966	1930	1930

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SECTION 4

INSTITUTIONS SUPPLYING WATER WITHIN THE WMA

The WMA is served by 29 individual systems, with the Potomac River providing 67 percent of the total regional demand. The remaining 33 percent is satisfied by the Patuxent River (14 percent), Occoquan Creek (13 percent), Goose Creek (2 percent), and groundwater and other sources (4 percent). Water pumped by source and by major purveyor in the Washington area is shown in Table 2. The three largest water suppliers are the WAD, the WSSC, and the FCWA. Together, they supply 92 percent of the water used in the area, with 49.3 percent provided by WAD, 29.8 percent by WSSC, and 13.1 percent from FCWA.

Several other water systems supply the remaining 8 percent of the total water used. The largest among these is the City of Rockville. The City of Fairfax and other suppliers normally do not draw water from the Potomac. It was assumed for this analysis that their future raw water would come from the Potomac. Several towns and a number of residents in the WMA rely on groundwater as a major or supplementary source of supply.

The WAD serves Washington, D.C., Arlington County, Falls Church, and parts of Fairfax County and Maryland. The WAD sells water to individual jurisdictions, but distribution is the responsibility of the local governments. WAD's only source of water is the Potomac River from which water is withdrawn at two pumping stations, one with a 200 MGD capacity at Great Falls, and the other with a 450 MGD capacity at Little Falls. Water is treated at the Dalecarlia and McMillan treatment plants (with combined peak capacity of 371 MGD) prior to distribution (Figure 6).(15)

The WSSC supplies water to Montgomery and Prince Georges Counties and to a small portion of Howard County in Maryland. WSSC's major source of water is the Potomac River; however, a portion of the water supply is obtained from two reservoirs, Triadelphia and Rocky Gorge, on the Patuxent River, with a combined usable water supply storage capacity of 10.1 billion gallons. The two reservoirs have a safe yield of 43 MGD, and a maximum yield of 65 MGD. The 65 MGD figure represents a maximum treatment plant capacity for a period of five months.(16) WSSC's major facility is a filtration plant on the Potomac River near Watts Branch, with a capacity of 240 MGD.

The FCWA, established by the Fairfax County Board of Supervisors, supplies wholesale and retail water to most of Fairfax County, the City of Alexandria, and Prince William County. Its major source of water is the

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TABLE 2. YEARLY RAW WATER DEMAND BY UTILITY (mil gal/year)

Source	Utility	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Potomac	WAD	73,810	70,455	69,349	72,703	73,274	75,675	78,462	74,164	74,199	75,959
	WSSC	22,620	23,374	26,390	27,144	28,652	27,260	28,566	30,966	30,127	32,621
	Rockville	1,354	1,391	1,500	1,625	1,555	1,555	1,714	2,226	1,793	1,876
Demand		97,784	95,220	97,239	101,472	103,481	104,490	108,742	107,356	106,209	110,456
Average MGD		268	261	266	278	284	286	298	294	291	302
Patuxent	WSSC	12,180	12,586	14,210	14,616	15,428	18,005	17,701	15,055	17,814	17,916
Ocoquan	FCWA	4,938	18,583	20,025	21,311	22,124	23,130	24,040	25,510	25,432	27,711
Groundwater	Leesburg	120	133	151	169	187	218	220	256	279	296
Demand		17,238	31,302	34,386	36,096	37,739	41,353	41,961	40,821	43,525	45,923
Average MGD		47	86	94	99	103	113	115	112	119	126
Total water demand		115,022	126,522	131,625	137,568	141,220	145,843	150,703	148,186	149,734	156,379
Average MGD		315	347	360	377	387	399	413	406	410	428

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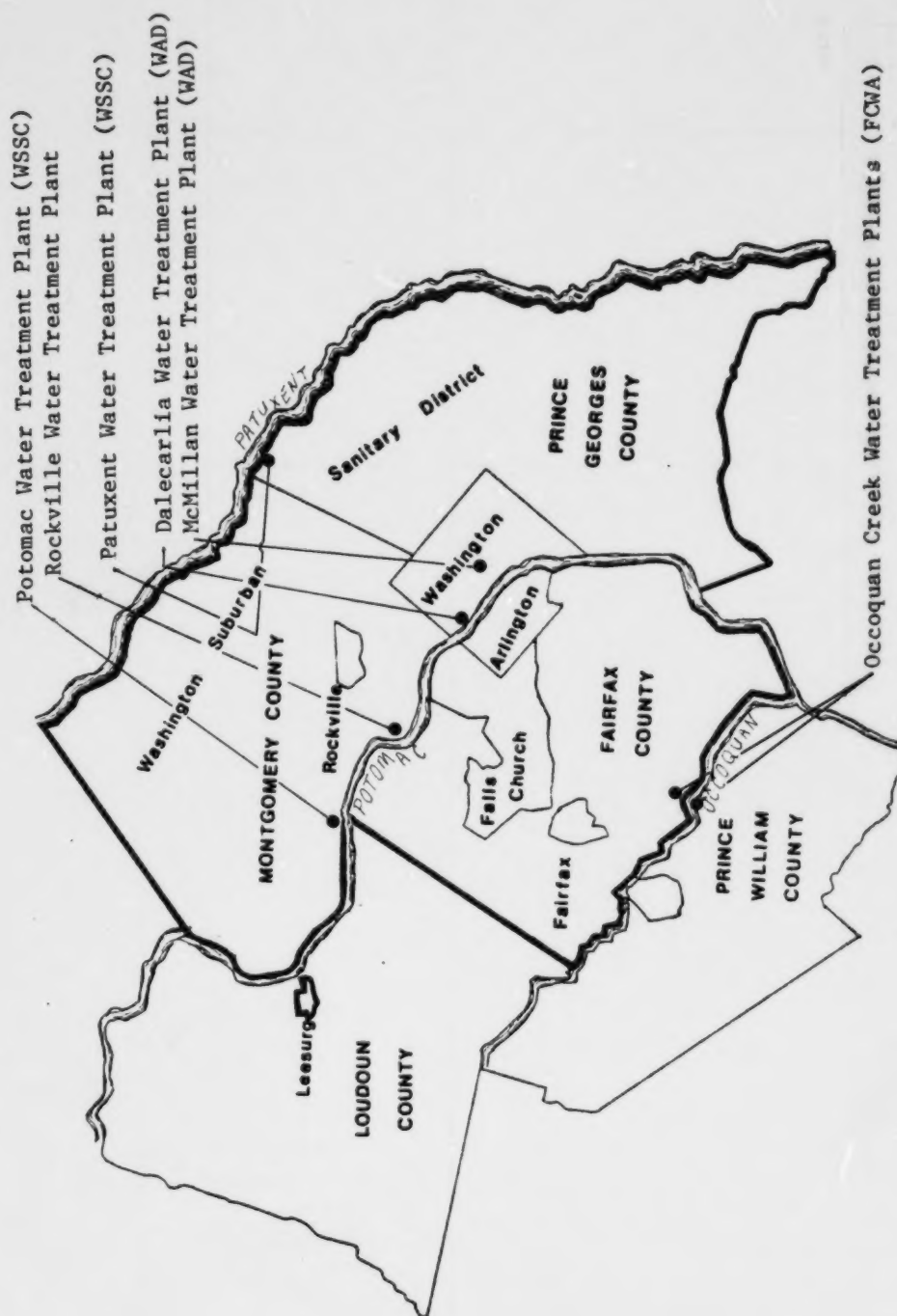


Figure 6. Water treatment plants serving the Washington Metropolitan Area.

Occoquan Reservoir, with a usable storage capacity of 9.2 billion gallons, a safe yield of 65 MGD, and a maximum yield of 98 MGD. The 65 MGD figure represents a maximum treatment plant capacity for a period of five months.(17)

Transfer of water among the utilities in the WMA is complex. Table 3 attempts to identify some of the major transfer points within the area. For example, WAD acquires water from the Potomac and supplies water to the D.C.-Department of Environmental Services (DES), Arlington and Falls Church in Virginia, and to utilities in Maryland. Falls Church, in turn, sells water to the FCWA, as well as to other utilities in Virginia. The FCWA sells water to the City of Alexandria, etc. These examples illustrate the complexity of finished water transfer from one point to another within the WMA.

Although the major water suppliers have plans for relying on the Potomac River for future water supply, the river itself is unregulated. The COE has proposed a number of alternative reservoir systems that would regulate Potomac River flows, but these plans have met with strong opposition from conservation groups and local citizens.

Two permits, one approved and one pending provide for construction of an expanded raw water intake for the WSSC at Watkins Island, Montgomery County, Maryland, and a 942-foot weir between the intake and Watkins Island. A new raw water intake for a proposed water treatment plant by the FCWA at Lowes Island, Loudoun County, Virginia, has been approved. The two permits are interdependent and represent construction of an intake system; the WSSC and FCWA intakes together represent a maximum 600 MGD withdrawal from the Potomac.(18)

In 1975, the COE completed a study of water supply problems in the WMA. The study identified several possible long-term solutions for the area. A follow-up study initiated by the COE, Baltimore District, is due to be completed in 1982. This study will make recommendations concerning possible solutions to the water supply problems in the WMA.(19)

Two projects recommended in earlier studies are nearing completion and will have a major impact on water supply in the area. A dam at Bloomington Lake on the North Branch of the Potomac River in West Virginia and Maryland will be operational in 1980, and will provide a supplemental supply of about 135 MGD to the river during low flow periods beginning in 1981. Construction of an emergency pumping station in the freshwater portion of the Potomac estuary near Chain Bridge has been completed. This facility is capable of supplying 100 MGD to the WAD on an emergency basis to augment the WAD's existing intakes should an unforeseen emergency occur; however, it is not to be a supplementary supply of potable water on a regular basis during periods of low flow.(20)

Recognizing the water supply problem, the various agencies involved (COE, the State of Maryland and the Commonwealth of Virginia, the FCWA,

TABLE 3. WHOLESALE WATER SALES IN WASHINGTON METROPOLITAN AREA (1976)

Supplier	Source	Customer	mil gal/year
WAD	Potomac	D.C.-DES	57,915.9
		Arlington	7,789.8
		Falls Church	6,532.6
		Maryland	8.1
FCWA	Occoquan Creek	Alexandria	5,471.99
	Purchased 1,562 mil gal	D.C. Reformatory	428.26
	Fairfax	Dulles Airport	111.71
	Falls Church	Fort Belvoir	788.92
	Vienna	Prince William County	1,564.36
	Loudon County	Prince William Water Co.	773.78
	Fort Belvoir	Miscellaneous	328.05
Rockville	Potomac		
	Interconnections with WSSC		
Leesburg	Groundwater		
Arlington County	Aqueduct		
	Total purchased 7,817.21 mil gal		
Falls Church	WAD	FCWA	1,306.1
	Interconnection with Arlington County	Vienna	793.6
		Arlington Co. (direct)	128 homes
		City of Fairfax	Emergency only
		(CIA)	(123.4) *
		(Melpar Complex)	(15.5) *
WSSC	Potomac-Patuxent	Howard County (direct)	To homes
		Rockville	
		D.C. Interconnection	

* Included in the Falls Church number of 1,306.1 mil gal/year.

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and the WSSC) developed an allocation agreement for distribution of water from the river if, in fact, demand should exceed supply. The concerned parties have reached an agreement on a suitable division of the Potomac River water during a low flow emergency. The Potomac Low Flow Allocation Agreement was signed by the Federal Government, the States of Maryland and Virginia, the District of Columbia, the WSSC, and the FCWA in January 1978. Appendix A contains a draft version of the Low Flow Agreement for informational purposes. The following section discusses some of the major supply and demand problems in the WMA.

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SECTION 5

CURRENT AND FUTURE DEMAND IN WMA

In this report, two types of demand will be considered. One is raw water (RW) demand, or water pumped to the treatment plants as shown in Table 2. The other is revenue-producing water (RPW), which is the water for which revenue is actually obtained. The difference between RPW and RW is the water lost due to backwashing, leaks, meter errors, and other non-revenue-producing uses, such as fire fighting. For the three purveyors - WSSC, WAD, and FCWA - the ratio of RPW to RW is 1.216; in other words, approximately 22 percent of the raw water in the WMA is used for non-revenue producing purposes. RW reflects hydraulic capacity requirements for the acquisition and treatment systems, but RPW is the basis upon which a utility must plan its budget.

RAW WATER DEMAND

Table 2 shows raw water demand by major purveyor and source for the period 1967 through 1976. As can be seen, WAD demand has stabilized over the 10-year period, while demand from WSSC and Rockville has continued to increase. Total demand on the Potomac has remained essentially constant over the last 10 years, while demand on the Occoquan, Patuxent, and groundwater has increased sharply. The capacity of these three sources has or will soon reach dependable yield limits and any future RW demand will therefore come from the Potomac.

The average monthly water pumped for 1976 by the three major water purveyors is shown in Table 4. The annual average monthly demand is less than the average monthly demand for June through September, clearly showing a peak in demand during the summer. Demand for water obviously varies significantly over time.

Four categories of demand will be used in this report to represent this time-dependent characteristic. "Average month" means the sum of the average water use for an individual year divided by 12. "Peak month" is the highest single monthly demand within a given year. "Peak 7 days" means the highest 7-day running average for the year and normally occurs during the peak month. "Peak day demand" is the highest 1-day demand in a given year and also generally occurs during the peak month. These categories apply to both RW and RPW.

Average monthly demand is probably the most stable and most easily

TABLE 4. AVERAGE RAW WATER PUMPED BY MAJOR PURVEYORS (1976)
(MGD)

Month	Purveyors		
	WSSC	FCWA	WAD
January	124	47.7	187.1
February	126	59.8	181.3
March	126	56.1	182.1
April	141	56.9	194.2
May	141	62.9	195.8
June	160	66.3	224.1
July	147	57.8	224.0
August	147	74.6	222.5
September	144	72.2	210.5
October	135	56.9	192.6
November	133	64.5	184.9
December	131	58.0	185.3
Annual	1655	733.7	2384.4
Average	138	61.1	198.7

calculated value. Therefore, the ratios of the various peak demand categories were calculated with respect to average monthly demand. Calculations were made for the ratios of average monthly demand to peak monthly demand, peak 7-day demand, and peak 1-day demand. These values were calculated for the entire WMA, but the data base was limited. The results were very close to those calculated in an earlier COE study. Since the COE numbers were based on more data the decision was made to use the COE values. The ratios presented in Table 5, and used in this analysis, are those calculated from the COE values.(21) As can be seen, the highest ratio of average monthly to peak monthly demand occurs in July, but peak 7-day and 1-day ratios are higher for August. These ratios are important for estimating future demand and characteristics. For example, it is possible to calculate the average monthly demand based on population growth and estimated per capita water use in a given year. Once this projection has been made, ratios such as those presented in Table 5 can be used to estimate peaking characteristics.

DEMAND FOR REVENUE-PRODUCING WATER

Table 6 shows the demand for RPW for the WMA by major purveyor. Tables 3 and 7 show that RPW has remained relatively constant as a percentage of RW over the 10-year period between 1967 and 1976.

Components of Demand

As discussed earlier, the basis for financial planning in a water utility is RPW. RPW, however, is supplied to various types of consumers. The rates charged these consumer classes are established according to utility accounting procedures. Each consumer class has its own growth and demand characteristics. It is therefore important to understand these various classifications. Table 8 shows various consumer classes for the WSSC. Not all utilities have such a detailed breakdown of the types of customers they serve. Because demand characteristics differ among customer classes, it is helpful to know the types of customers to which water is supplied.

For purposes of this study, the demand categories were broken into residential use and nonresidential use. Residential use was assumed to be a function of the number of people residing in a water service area, and nonresidential use was assumed to be a function of employment.

Table 9 shows the total RPW demand, total residential population, total employment, and per capita residential and nonresidential consumption for D.C., DES, WSSC, and the combined Virginia utilities (FCWA, Arlington, and Falls Church) previously discussed. The figures show that consumption varies widely within the residential and non-residential categories. One can theorize about some of the differences in demand shown in Table 9. For example, the low per capita residential consumption in D.C.-DES may be a result of the number of apartments and condominiums in the D.C. area thereby reducing household water use. In the WSSC and Virginia service areas, many of the residences are single-family homes in

TABLE 5. DEMAND RATIOS FOR WMA*

Month	Ratio of average month to:		
	Peak monthly average	Peak 7 days	Peak 1 day
July	1.19137	1.27477	1.40582
August	1.15593	1.32932	1.47959
September	1.10393	1.20328	1.28056
October	0.99877	1.02873	1.07867
November	0.94830	0.98623	1.01468

* Calculated from Northeastern U.S. Water Supply Study (NEWS).

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TABLE 6. REVENUE PRODUCING WATER BY MAJOR PURVEYOR (mil gal/year)

Major purveyor	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
WAD	—	47,145	60,362	61,084	64,353	64,112	62,514	63,175	61,169	55,335
WSSC	30,000	31,000	35,000	36,000	38,000	38,000	39,000	40,000	42,000	42,000
FCWA	3,950	14,866	16,020	17,049	17,699	18,504	19,232	20,408	20,346	22,169
Rockville	1,083	1,113	1,200	1,300	1,244	1,244	1,371	1,781	1,434	1,501
Leesburg	94*	104*	118*	132*	146	170	172	201	218	266
Total	—	94,228	112,700	115,565	121,442	122,030	122,289	125,565	125,167	121,271

* Estimated

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TABLE 7. RATIO OF RAW WATER TO REVENUE-PRODUCING WATER
FOR MAJOR PURVEYORS

Major purveyor	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
WAD	--	0.64	0.87	0.84	0.88	0.84	0.80	0.85	0.82	0.73
WSSC	0.86	0.86	0.86	0.86	0.86	0.84	0.84	0.87	0.83	0.83
FCWA	0.80	0.80	0.80	0.80	0.84	0.80	0.80	0.80	0.80	0.80
Rockville	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Leesburg	--	0.78*	0.78*	0.78*	0.78	0.78	0.78	0.79	0.78	0.90
Total all purveyors	--	0.74	0.86	0.84	0.86	0.84	0.81	0.85	0.84	0.78

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TABLE 8. NUMBERS AND TYPES OF CUSTOMERS FOR WSSC (1977)

Customer class	No. of accounts	Consumption (Mg/Year)
Residential	11,970	8,007,993
Commercial	1,698	1,956,627
Highrise	21	9,182
Garden appartments	10	54,488
Federal	34	1,472,765
State	10	464,219
County	226	1,120,498
Industrial	0	--*
Institutional	1	1,678
Total	13,970	13,087,450

* Information not available.

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TABLE 9. RESIDENTIAL AND EMPLOYMENT DEMAND FOR MAJOR WWA UTILITIES (1976)

Utility	Yearly		Yearly		Total RPM demand (mil gal/yr)	Total residential population	Total employment
	Residential demand (mil gal)	(gal/capita)	Nonresidential demand (mil gal)	(gal/capita)			
D.C.-DES	13,257	.01789	34,440*	.05217	47,697	741,000	660,100
WSSC	32,089	.02611	9,911	.02229	42,000	1,228,920	444,653
Virginia	32,931	.03489	7,675	.01870	40,606	943,824	410,383

* Includes apartments

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which lawn watering is a major factor in water demand.

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Nonresidential consumption for D.C.-DES is very high, which may be a result of the large number of older office buildings. For WSSC and Virginia, nonresidential use is lower. Most employment in the suburbs is in small businesses or commercial establishments. Many of these facilities are new and may have better water usage controls. D.C.-DES also has a large transient population of tourists and daytime office workers who live in the Virginia suburbs. The office workers who work in but live outside of D.C. may contribute to high water usage in the nonresidential category for D.C.-DES and in the residential category for Virginia and WSSC. The water used by many Federal installations, such as the Pentagon, Andrews Air Force Base, Washington National Airport, and the Defense Mapping Agency, is also included in the nonresidential category.

Although these categorizations are gross, dividing water usage into residential and nonresidential demand provides some basis for analyzing demand patterns among different types of customer classes. In the following section, residential and nonresidential demands are used to project water usage for the WMA.

GROWTH IN THE WMA

The WMA covers 2,326 square miles, including Montgomery and Prince Georges Counties in Maryland, and Arlington, Fairfax, Loudoun, and Prince William Counties in Virginia. Charles County in Maryland completes the Standard Metropolitan Statistical Area (SMSA). The WMA, which is one of the fastest growing metropolitan areas in the nation, is growing most rapidly at its fringes.(22)

Growth patterns significantly affect both the quantity and end use point of water required to satisfy consumer demands in the WMA. For purposes of this report, data from the U.S. Army Corps of Engineers and the Washington Metropolitan Council of Governments were used as the basis for population and employment projections.(23, 24)

One of the techniques used for population projections incorporates segmenting the WMA into Planning Analysis Districts (PAD). Figure 7 shows population by PAD in the WMA for 1970, and Figure 8 shows the estimated population in 1995. Figure 9 shows percent increase in population from 1970 to 1995. Figures 10, 11, and 12 show the same relationships for changes in employment. Figures 7 through 12 illustrate some of the dramatic changes that may take place in the WMA in the near future. PAD population and employment data were not available after 1995, but projections by political jurisdiction were available from the COE through 2030. Regression equations were developed to extend COE's projections to 2050. These population projections are discussed in detail in Appendix B. These figures have recently been revised by the Corps of Engineers (Spring of 1979), but the new values as reflected in the Corps of Engineers WMA study are very close to the projections used in this study.

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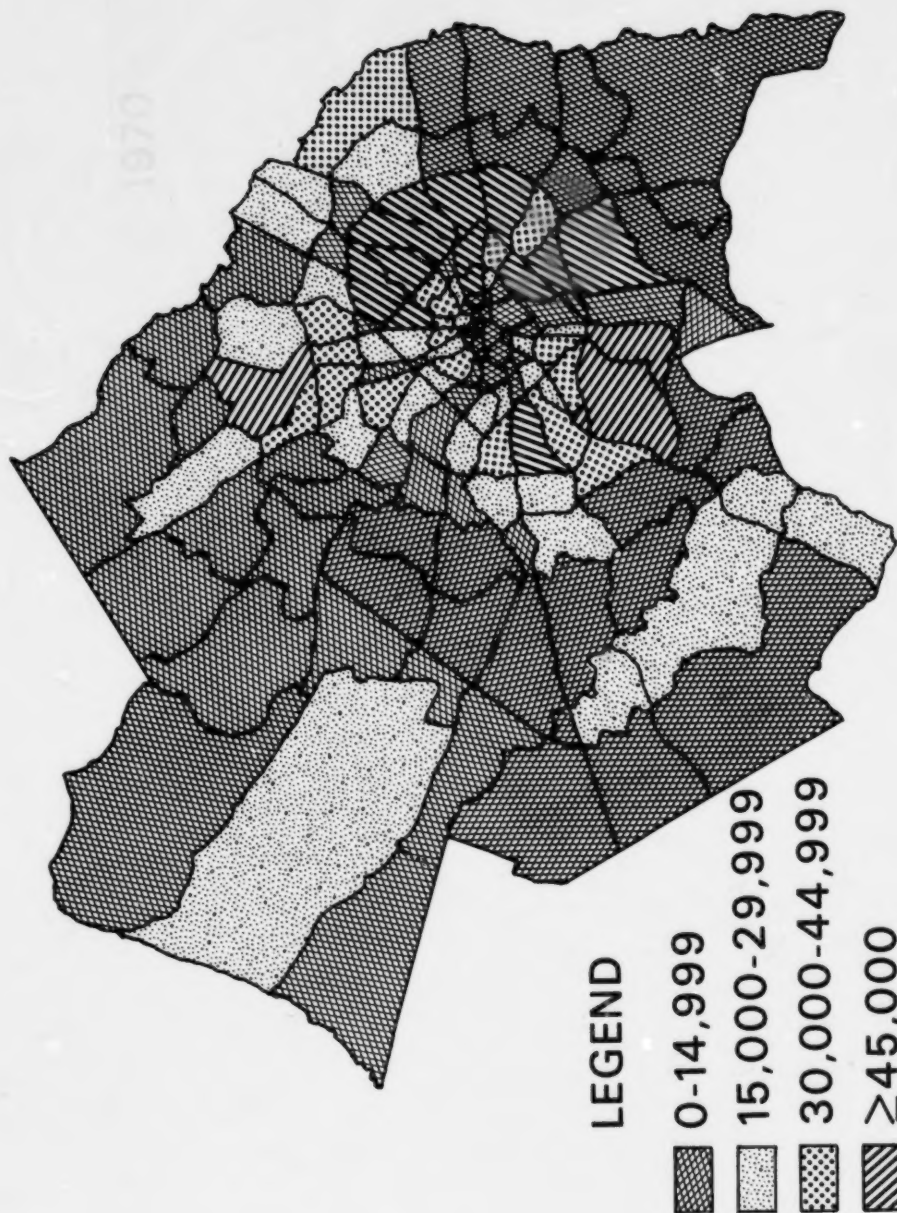


Figure 7. Population in Metropolitan Washington by PAD (1970).

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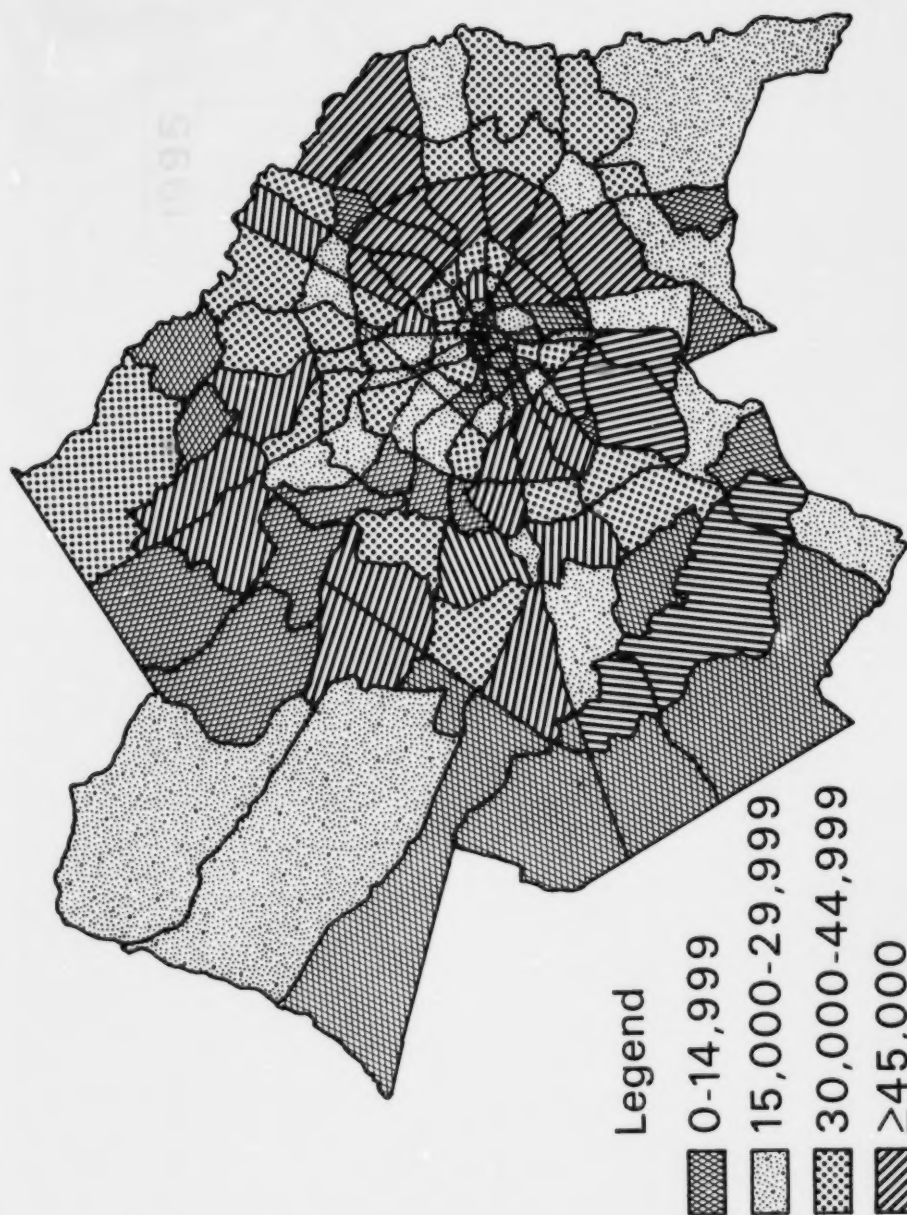


Figure 8. Population in Metropolitan Washington by PAD (1995).

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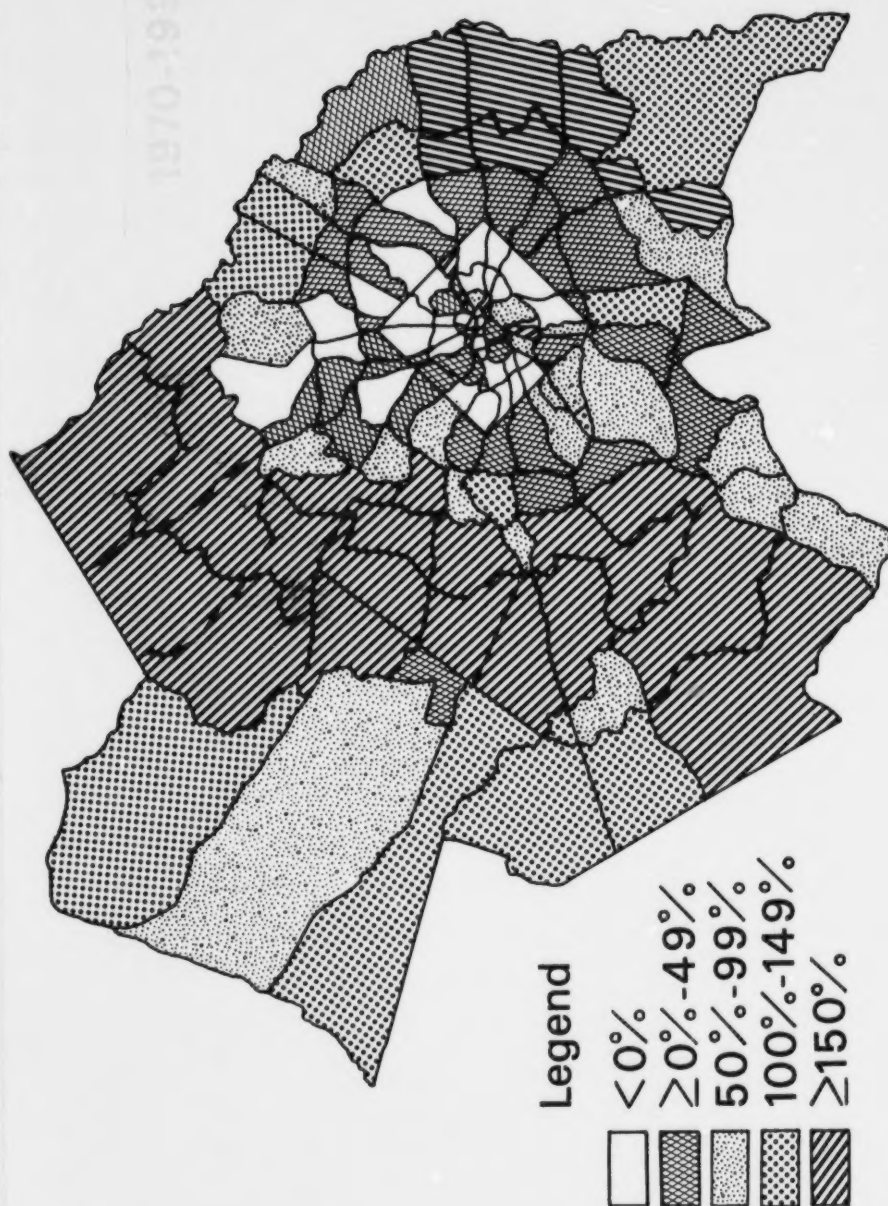


Figure 9. Percent change in population in Metropolitan Washington by PAD.

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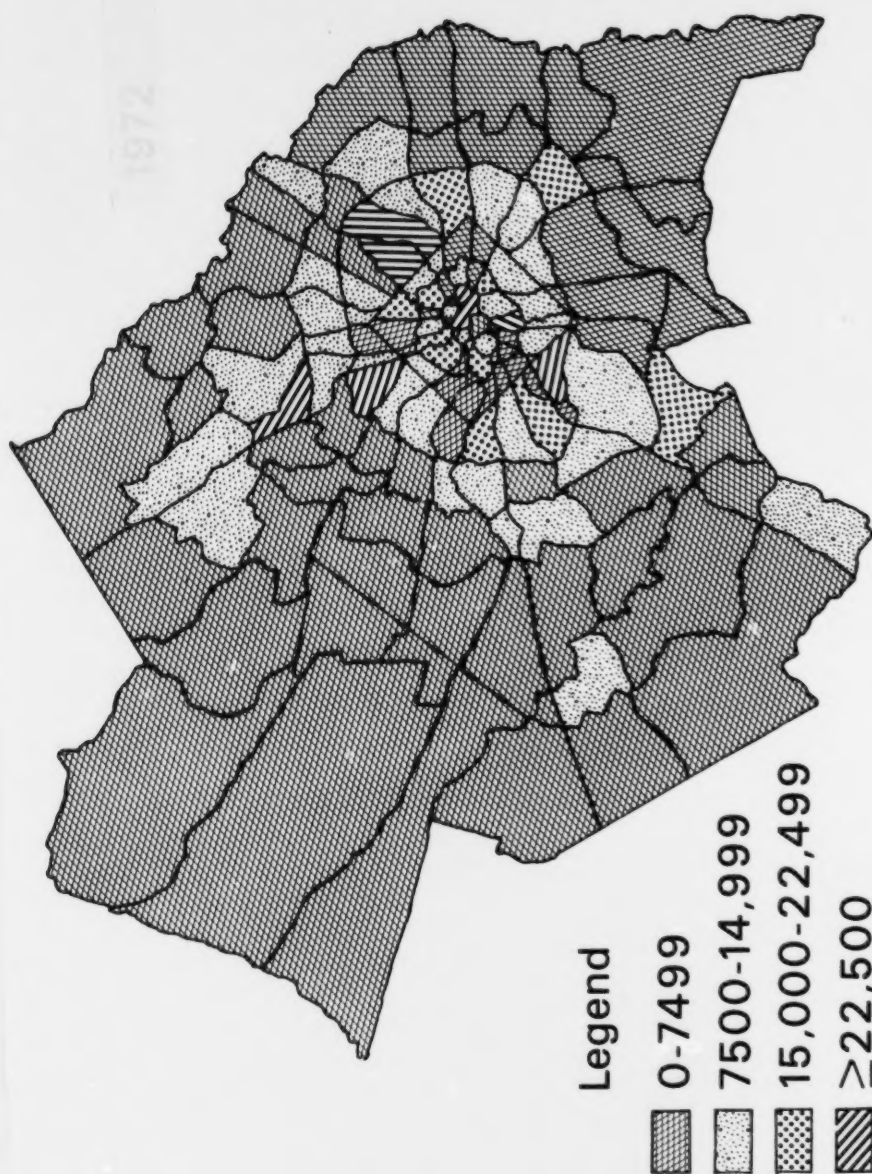


Figure 10. Total employment in Metropolitan Washington by PAD (1972).

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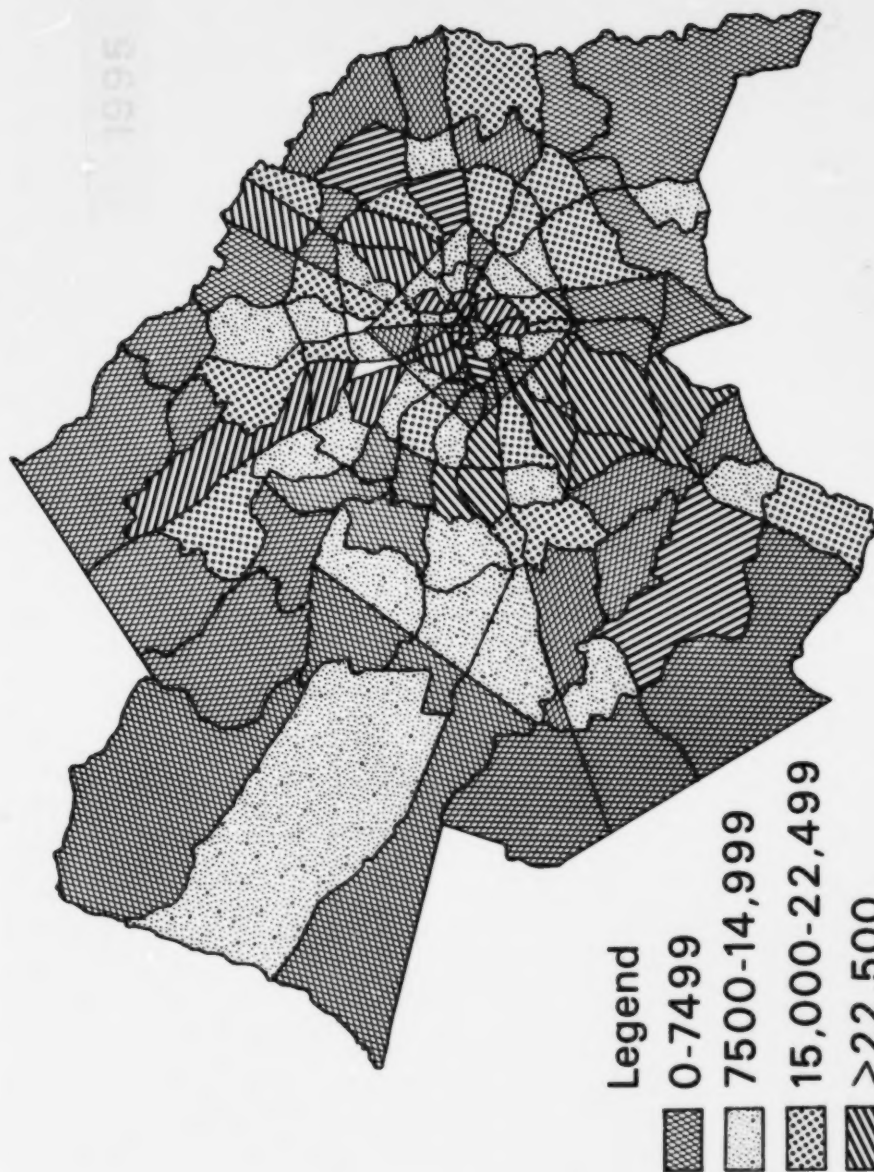


Figure 11. Total employment in Metropolitan Washington by PAD (1995).

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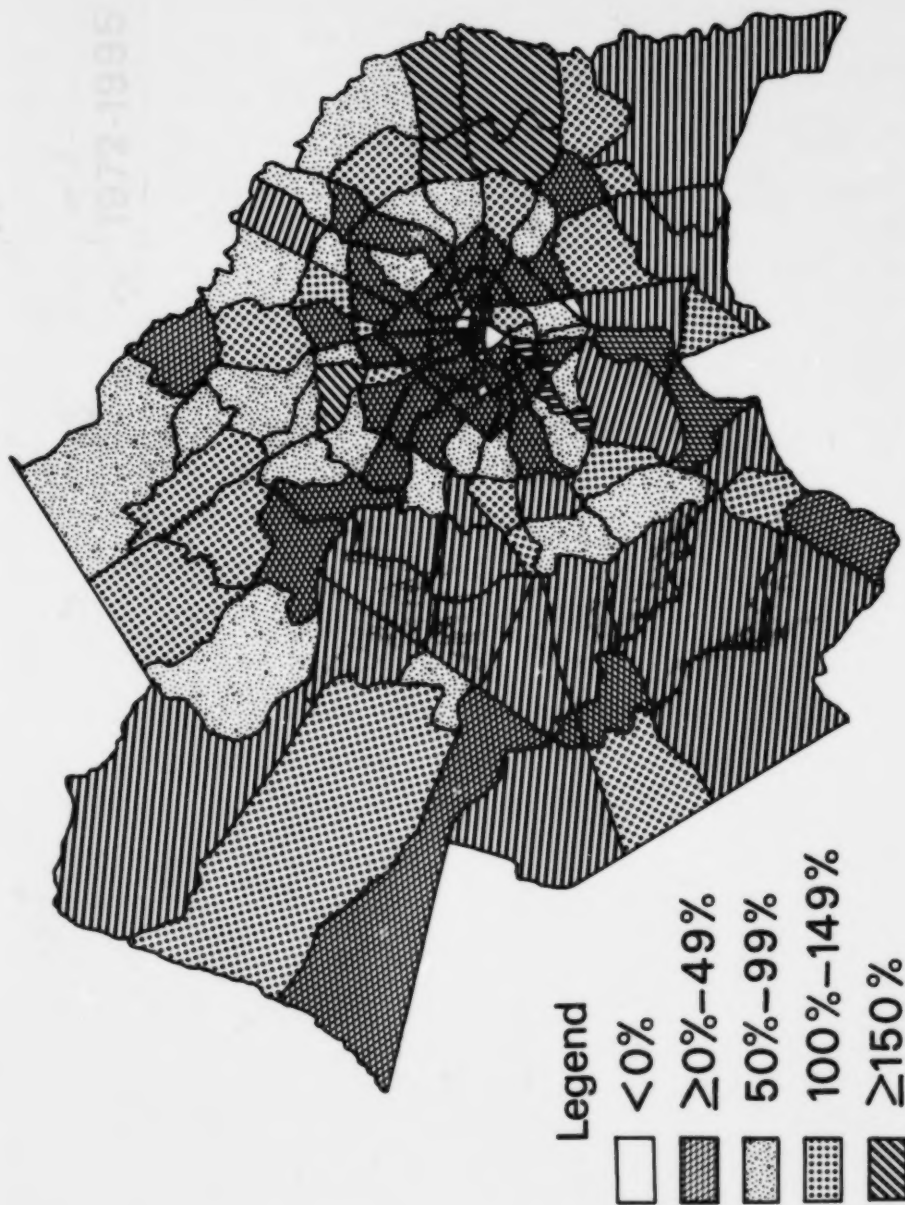


Figure 12. Percent change in employment in Metropolitan Washington by PAD.

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The actual and projected population and employment growth figures were combined with assumed residential per capita and per employee water demand to estimate total water demand for the WMA. Several scenarios were hypothesized and are summarized in Table 10. These scenarios ranged from a growth in per capita and per employee water use of 10 percent per 10-year period to a decrease of 5 percent per capita and per employee per 10-year period. Based on data developed in Appendix B, Figure 13 shows the resultant change in Potomac demand for the six different scenarios. These curves are based on the assumption that the Occoquan, Patuxent, and others supply a steady yield of 121 MGD. Table 11 shows projected water requirements for Scenario 4 (constant water use). Line 1 of Table 12 shows the average monthly use based on the annual requirements listed in Table 11. Table 12 also shows various peaking requirements based on the average monthly use and the ratios in Table 5.

The peak monthly demand for raw water in 2050 is expected to reach 1,180 MGD, which exceeds six of the minimum monthly flows shown in Table 1 (Point-of-Rocks gauge). This disparity between projected demand and historical flow illustrates the problem that may ultimately face Potomac River water users.

The calculated demand projections can be used to illustrate the problems associated with using the unregulated Potomac as the only source of additional raw water for the WMA. Figure 14 is a plot of four different raw water demands (Table 12) and three different historic unregulated low flow conditions versus time.(25) The solid lines represent the demand condition: raw 1-day peak demand; raw 7-day peak demand; raw peak demand; raw average monthly demand. The dotted lines represent three historic low flows in the Potomac: 7-day 1930; 1-day 1930; and 1-day 1966. The average monthly demand exceeds all three supply conditions after the year 2000. The other demand conditions exceed all three flow conditions at an even earlier date. The graph can be used to illustrate the problem of water supply in the WMA. For example, in the year 2050 the projected raw water peak 1-day demand exceeds the 1966 1-day flow by nearly 1,100 MGD.

Comparing various flow conditions against demand projections provides insight into the capability of the Potomac to meet future demands. Figure 14 shows, superficially at least, that even under the most optimistic conditions deficits will probably occur between 1990 and 2000. The basic issue in this analysis is the tradeoff required to meet the various deficits, given any set of flow conditions.

If, for example, additional source water could be provided to meet the deficit resulting from the occurrence of a 1-day 1966 flow condition and the 1-day peak demand in 2050, the risk of ever experiencing that flow deficit will be extremely low, but the associated cost may be high. If sufficient flow is provided to meet the simultaneous occurrence of the 7-day 1930 low flow and the average peak month demand for 2050, the requirement for additional source water is significantly less and therefore less costly, but the risk of a deficit may be great. One must therefore balance the risk of failing to meet demand on the one hand against the cost of augmenting supply on the other. Some of the available options

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TABLE 10. PER CAPITA WATER USAGE SCENARIO

Scenario	Description of per capita change over 10-year period
1	Growth in per capita and per employee water usage over entire WMA of 10%.
2	Growth in per capita and per employee water usage over entire WMA outside of D.C. of 10% but a decrease of 5% per capita and per employee use in D.C.
3	Maximum growth in per capita and per employee water usage over entire WMA of 5%.
4	No growth in per capita and per employee water usage over entire WMA; current use assumed constant.
5	Decrease of 5% per capita and per employee use in D.C., and constant (no increase) use elsewhere in D.C. area.
6	Decrease of 5% per capita and per employee use over entire WMA.

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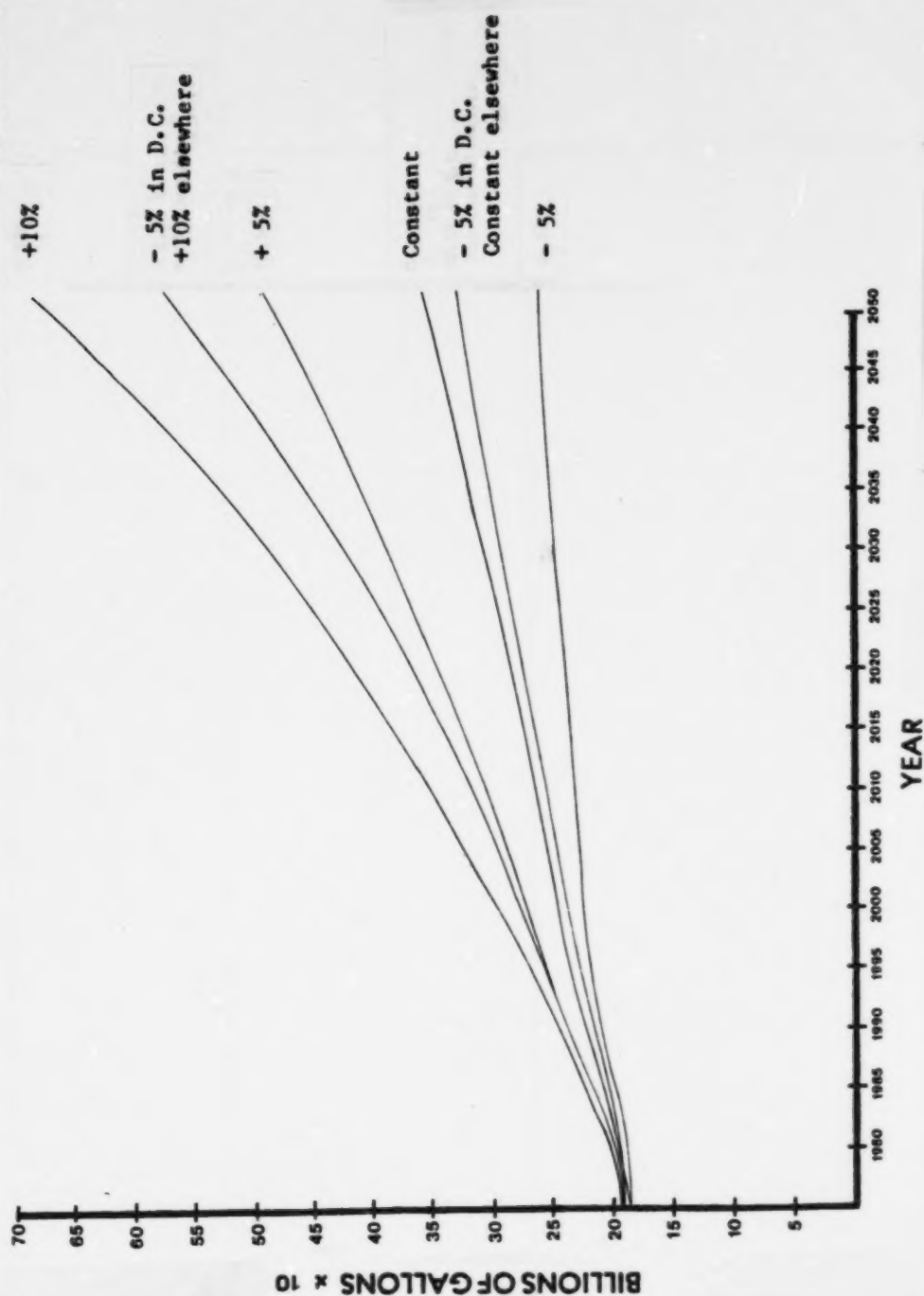


Figure 13. Future water use (Z changes are over 10 year periods) under different water demands.

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TABLE 11. PROJECTED ANNUAL REQUIREMENTS FOR REVENUE-PRODUCING WATER (mil gal/year)
(Based on scenario 4)

Area	1976	1980	1985	1990	1995	2000	2005	2010
Washington (MGD)	47,199	49,687	51,965	53,569	55,812	57,752	59,816	61,738
Virginia (MGD)	129	136	142	147	153	158	164	169
Maryland (MGD)	40,603	45,681	51,732	57,789	63,313	67,549	71,166	75,238
TOTAL RPW (MGD)	111	125	142	158	173	185	195	206
Washington (MGD)	42,874	46,228	52,324	58,633	64,321	68,842	73,839	78,418
Virginia (MGD)	117	127	143	161	176	189	202	215
TOTAL RPW (MGD)	130,676	141,596	156,021	169,991	183,446	194,143	204,821	215,394
	357	388	427	466	502	532	561	590
Area	2015	2020	2025	2030	2035	2040	2045	2050
Washington (MGD)	63,659	65,509	67,359	69,209	71,149	73,035	74,921	76,807
Virginia (MGD)	174	179	185	190	195	200	205	210
Maryland (MGD)	79,798	83,555	88,949	93,443	98,349	102,838	107,187	111,571
TOTAL RPW (MGD)	219	229	244	256	269	282	294	306
Washington (MGD)	82,920	86,175	91,347	95,092	98,855	103,245	107,608	111,997
Virginia (MGD)	227	236	250	260	271	283	295	307
TOTAL RPW (MGD)	226,377	235,239	247,655	257,744	268,353	279,118	289,716	300,375
	620	644	679	706	735	765	794	823

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TABLE 12. WASHINGTON METROPOLITAN AREA WATER DEMAND (MGD) BY CATEGORY

Item	1976		1980		1985		1990		1995		2000		2005		2010	
	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW
Average month	358.0	435.3	387.9	471.7	427.5	519.8	465.7	566.3	502.6	611.2	531.9	646.8	561.2	682.4	590.2	717.6
Peak month	413.8	503.2	448.4	545.3	494.1	600.8	538.3	654.6	581.0	706.4	614.8	747.6	651.4	792.0	685.9	834.0
Peak 7 days	475.4	578.7	515.7	627.1	568.2	691.0	619.1	752.8	668.1	812.4	707.1	859.8	746.0	907.1	784.6	954.0
Peak 1 day	529.7	644.1	574.0	698.0	632.5	769.1	689.1	837.9	743.6	904.3	787.0	957.0	830.3	1009.6	873.3	1061.8

Item	2015		2020		2025		2030		2035		2040		2045		2050	
	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW	RPW	RW
Average month	620.3	754.2	644.5	783.7	678.6	825.1	706.2	858.7	724.2	880.5	753.2	915.8	782.8	951.8	811.7	987.0
Peak month	722.1	878.0	750.9	913.0	791.2	962.0	824.1	1002.0	865.2	1052.0	900.6	1095.0	935.1	1137.0	970.5	1180.0
Peak 7 days	824.6	1002.6	856.7	1041.7	902.1	1096.8	938.8	1141.0	962.7	1170.5	1001.2	1217.4	1040.6	1265.3	1079.0	1312.0
Peak 1 day	917.8	1115.9	953.6	1159.5	1004.0	1220.8	1044.9	1270.5	1071.5	1302.9	1114.4	1355.0	1158.2	1408.3	1201.0	1460.3

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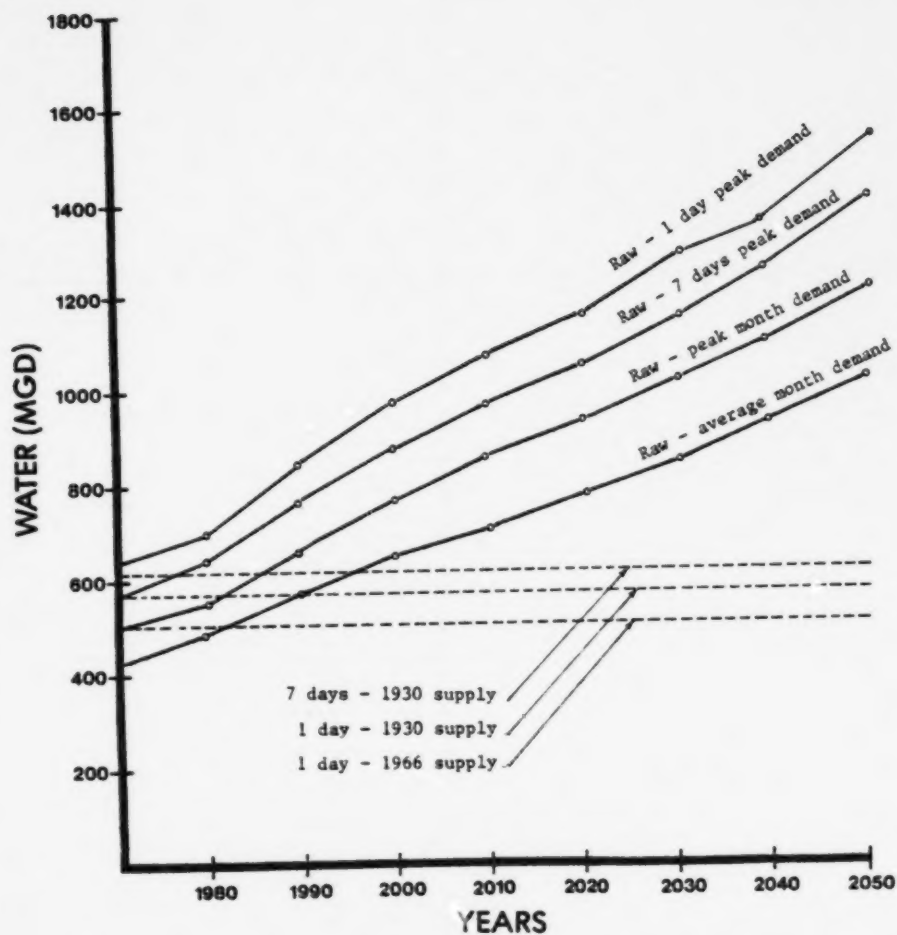
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Figure 14. Supply and demand relationships.

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for providing additional supply are the construction of reservoirs or renovated wastewater plants. Another option that might be considered is conservation. Conservation will not only reduce average demand but may substantially reduce peak demands as well.

There are plans currently in existence to satisfy some of the possible deficits which may occur in the future. For example, construction of the Bloomington Reservoir will provide 135 MGD during low flow periods. This, along with other existing sources such as the Patuxent, will provide a total of 256 MGD during low flow periods. Taking the average flow conditions for the last 17 years from 1959 to 1975 (787 MGD), adding the Bloomington flow (135 MGD) and the other WMA water (121 MGD), and subtracting 100 MGD to maintain estuary flow would provide 943 MGD of available supply in the Potomac. If this supply is compared against the average monthly demand curve for Potomac users in Figure 14, it can be seen that no deficits would occur until after 2030. However, if the same supply level is compared with the peak monthly demand, deficits would occur before 2000. In 10 of the 17 years, the average unregulated Potomac flow was below 787 MGD - in some cases, for considerable lengths of time.

From the above discussion, it is obvious that the specific supply and demand conditions used for comparison are critical to any analysis. Various levels of protection can be purchased, and the cost of each level of protection must be examined against its anticipated benefits. Maximum protection and an associated low risk may have a higher price than a low level of protection with a high risk. Analysis of water supply alternatives and their associated costs is much like evaluating the desirability of purchasing an insurance policy: the potential benefits must be weighed against the risks.

Figure 14 illustrates the kind of thinking required for effective analysis but assumes static flow conditions for a given demand or supply scenario. It illustrates the important features of an evaluation, that is it includes projections of demand versus supply, but because flows are erratic in the Potomac, an approach that considers the dynamic nature of demand and supply should be used. Such an approach is discussed in the following section.

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SECTION 6

DEFICIT FLOW ANALYSIS

To account for the dynamic nature of supply and demand conditions in the Potomac, a deficit flow analysis was made. The total water deficit is the amount of water required to meet estimated water supply demands over and above available flow in the Potomac and can be derived from historical records and estimated demand conditions.(26)

Figure 15 illustrates the principle of the deficit analysis approach. The jagged line is the historical river flow for 1966, and the horizontal lines are projected monthly demands for 1980, 2030 and 2050. The shaded areas between the demand and supply lines represent potential deficits in supply. This approach was used to analyze flow requirements to satisfy projected demands in the following analysis.

All of the following flow computations are based on the assumption that the Patuxent, Occoquan, Goose Creek, Broad Run, and groundwater are able to supply a safe yield of 121 MGD. A 2-day finished water storage capacity is also assumed within the WMA. A 100- MGD minimum flow is assumed in the Potomac to maintain in-stream flow. Table 13 shows the estimated monthly demand conditions for 1980 and 2050 based on the assumption of constant per capita and per employee water use over the period of analysis, and the flow conditions listed above.

As mentioned earlier, the most reliable river gauge in the D.C. area is the Point of Rocks gauge, several miles upstream from the WMA inlets. However, four streams enter the Potomac just above the WMA but below the Point of Rocks gauge. The contribution of these four streams to the flow of the Potomac was simulated to make estimated available flow conditions more realistic.

A computer program was developed to account for stream flows at the following points: the Potomac at Point of Rocks, Maryland; Seneca Creek at Dansville, Maryland; Difficult Run near Great Falls, Virginia; and Goose Creek near Leesburg, Virginia.(27)

Because most of the water in the Potomac passes the river gauge at Point of Rocks, Maryland, the daily flows at Point of Rocks were examined, through the use of a computer, for the years 1909 to 1975. Daily flows for June through December, which is the period of greatest demand in the WMA and the lowest flow in the Potomac, were entered into a data base. The contributions made by the other four streams to the Potomac flow were

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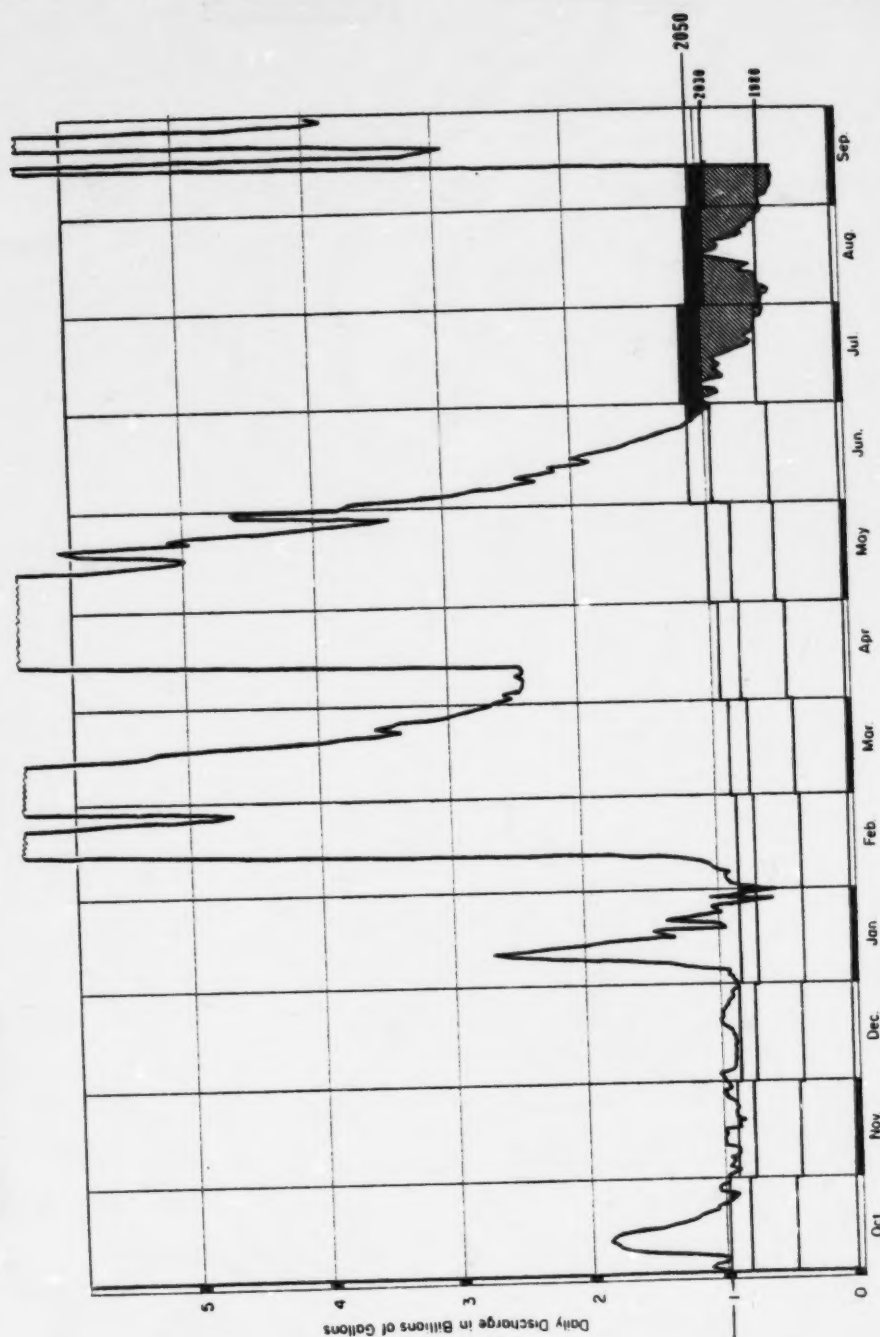


Figure 15. Deficit flow conditions for 1980, 2030, and 2050 demand versus 1966 river flow.

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TABLE 13. MONTHLY DEMAND WITHOUT CONSERVATION FOR 1980 and 2050

Year	Monthly demand in MGD											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1980	450	462	412	388	388	403	419	457	499	541	524	500
2050	986	935	905	854	853	884	920	1001	1090	1180	1144	1092

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estimated by calculating the ratio of their low flows to the low flow in the Potomac during the 6-months period. Runoff was accounted for by a drainage factor for each stream. A regression equation was developed whereby the total flow in the Potomac was estimated by adding the flow for the tributary streams to the monthly low flow in the Potomac at Point of Rocks (see Appendix C). Using this approach, the historical flows above the WMA were compared with the estimated water supply demands. The actual historical Potomac flows were compared against estimated future demand. The following section examines some of these data.

DEFICIT FLOW ANALYSIS RESULTS

Figure 16 shows annual deficits for the simulated 2030 and 2050 demand versus the historical flow in the Potomac. As can be seen, the three historic flows that yield the most severe deficits for the 2030 and 2050 demand are 1930, 1966, and 1932, respectively. Each of these deficits represents a different risk as shown by the magnitude of the deficit. For example, should the 1930 flow condition occur again, deficits will be the most severe, representing the highest risks. The 1932 flow condition will also cause a deficit but is less severe, representing a lower risk.

Figure 17 shows the frequency of yearly deficits when historic flow is compared against estimated demand for individual yearly demand between 1980 and 2050. By 2050, based on a 61-year record, there will be nearly 50 historic flow records in which deficits occur. According to Figure 18, there will be nearly 300 deficit periods. A deficit period occurs when the available raw water is less than the demand for raw water. Several deficit periods may occur in a single year. The probability of having a severe deficit increases dramatically with time. Figures 19, 20, and 21 indicate the magnitude of the yearly deficits for the three flow conditions in 1930, 1966, and 1932. Deficit magnitudes are significantly greater under 1930 river flow conditions than under 1932 flow conditions. As shown in Figures 17 and 18, the probability of deficits occurring in the future is high. Based on the stated assumptions, the probability of having a large number of deficit periods in a given year increases with time.

Deficit pattern is also very important. Figures 22 and 23 show the deficit position in time for the 1966 and 1930 river flows against 2030 and 2050 demand conditions. As can be seen for the 1966 flow, the deficit for June through December is greater than the surplus, but some surplus does occur between deficits. For the 1930 flow conditions, there is almost no surplus. The deficits in 2050 become deeper and for a longer period of time compared to those in 2030. These figures show that the shape of the deficits may be important in solving water shortage problems. For the 1966 river flow condition, deficits are of short duration, but deep. The 1930 deficit conditions are long and not so deep. Therefore, any facilities built to alleviate the 1966 shortage will require a large peaking capacity and will have to operate over a short time period. For the 1930 condition, deficits could be satisfied by facilities with lower peak capacity but operating over a longer time period. The deficit

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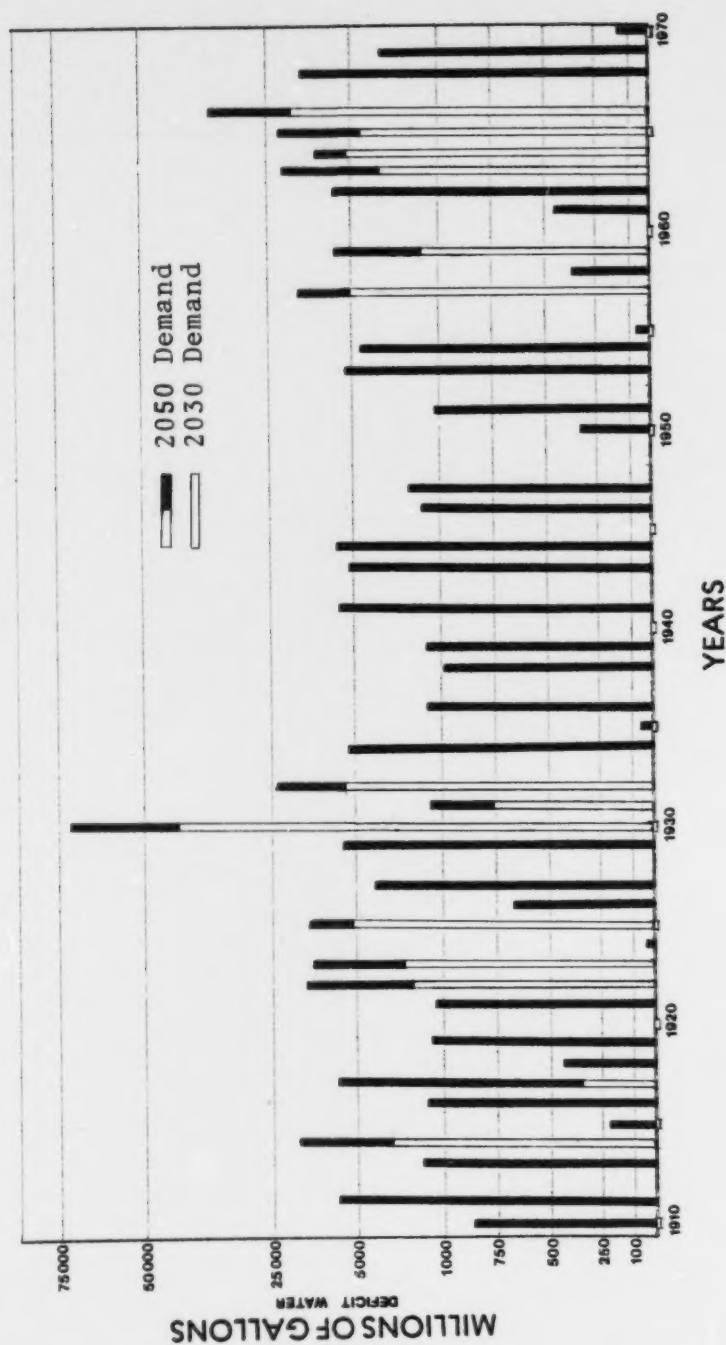


Figure 16. Deficit flow history based on 2030 and 2050 estimated demand.

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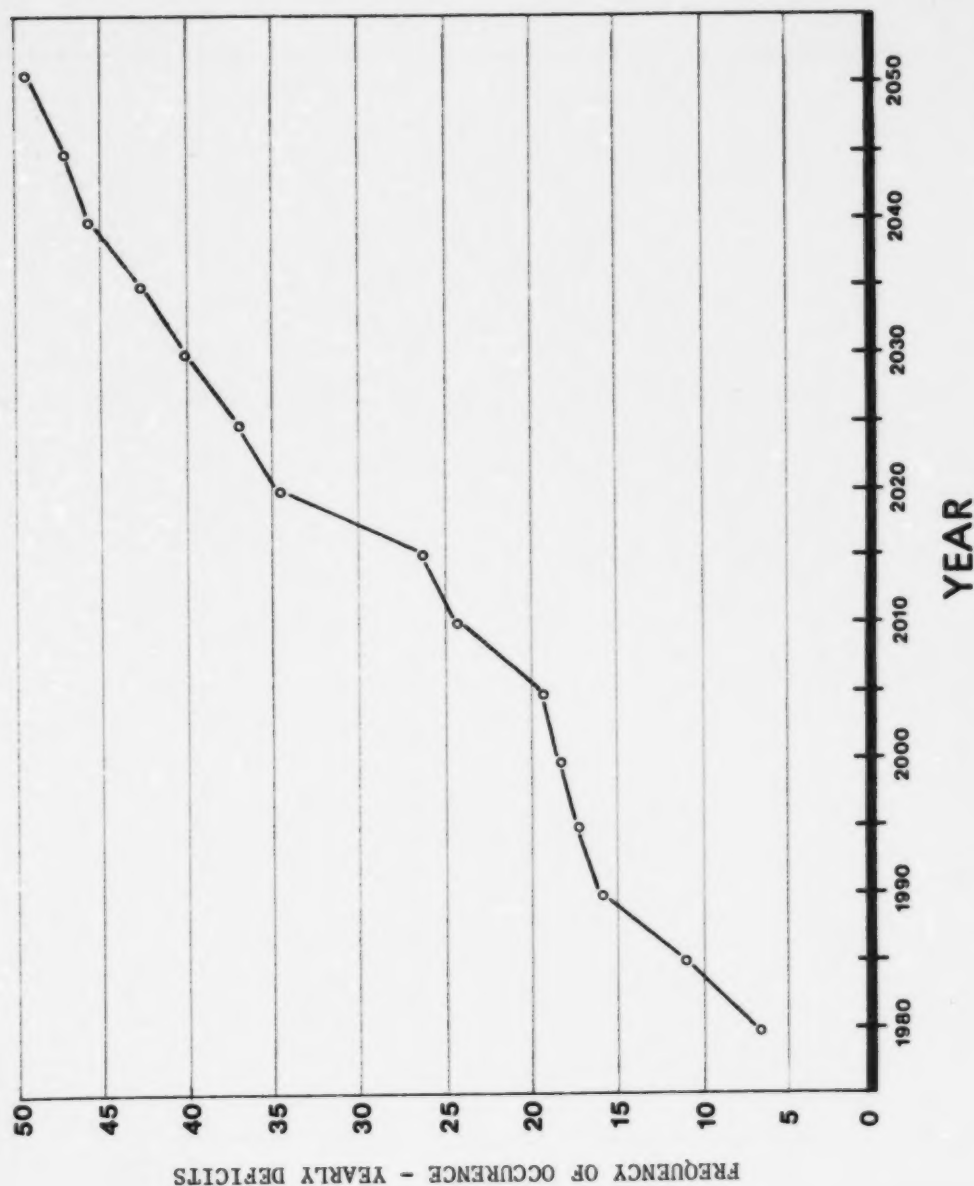


Figure 17. Frequency of yearly deficits vs. historical flow records.

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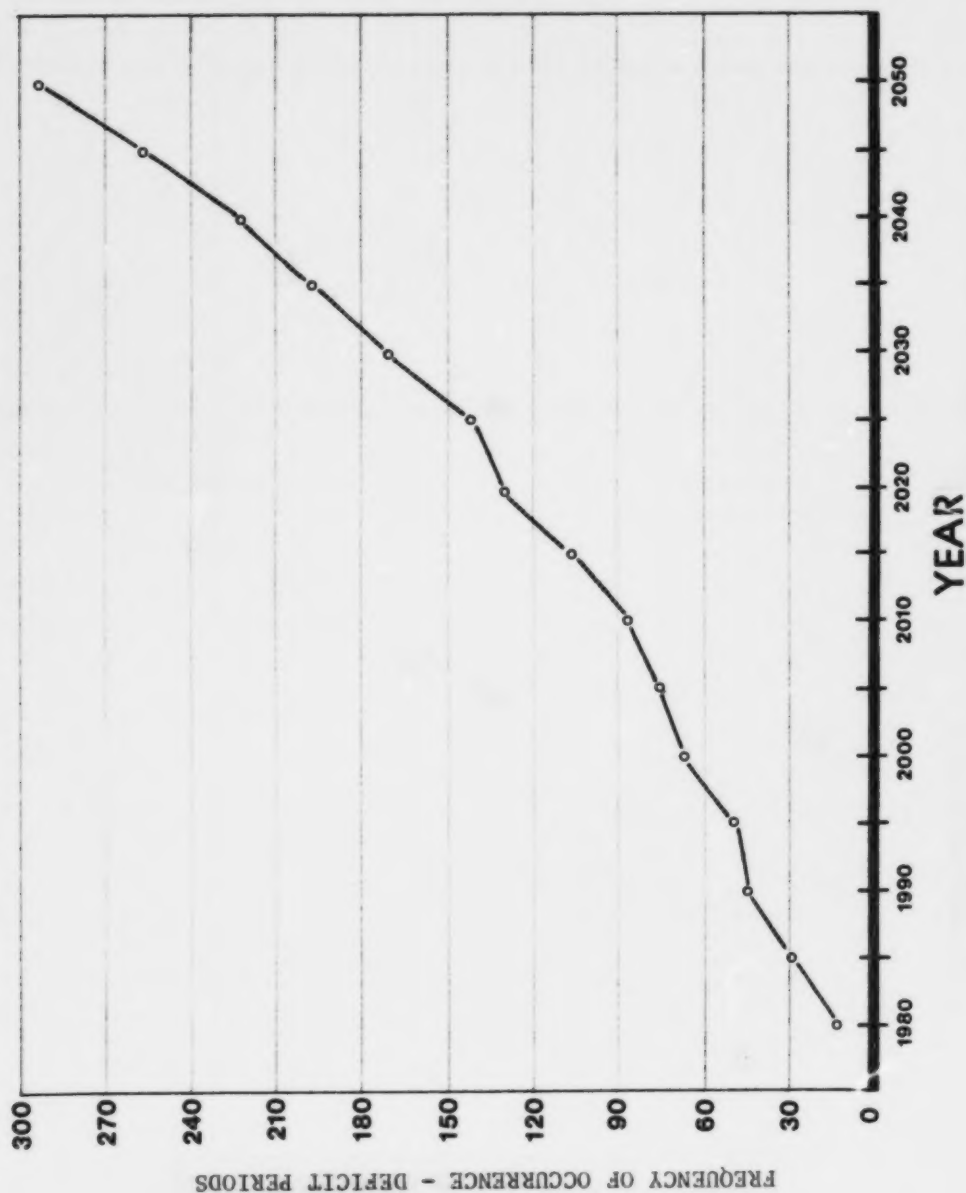


Figure 18. Frequency of deficit periods vs. historical flow records.

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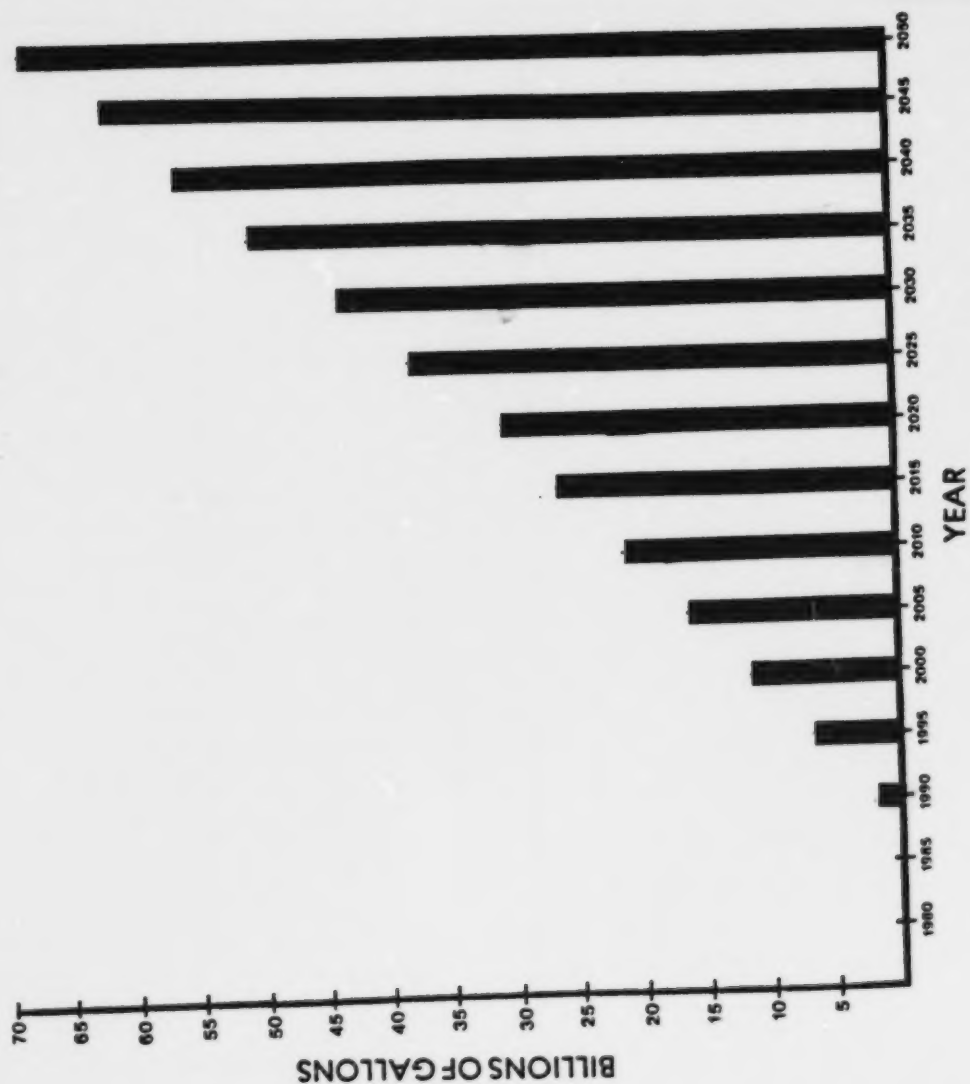


Figure 19. Magnitude of yearly deficits (1930 river flow).

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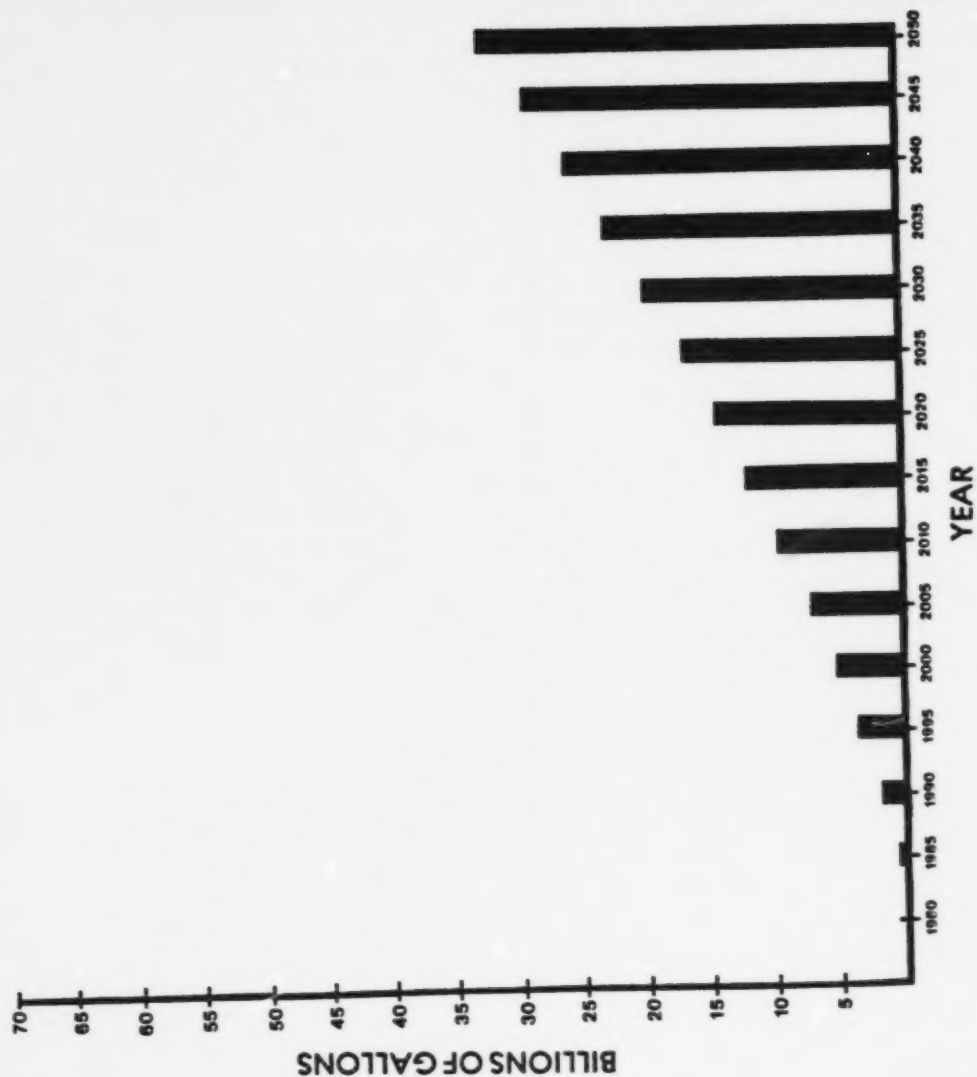


Figure 20. Magnitude of yearly deficits (1966 river flow).

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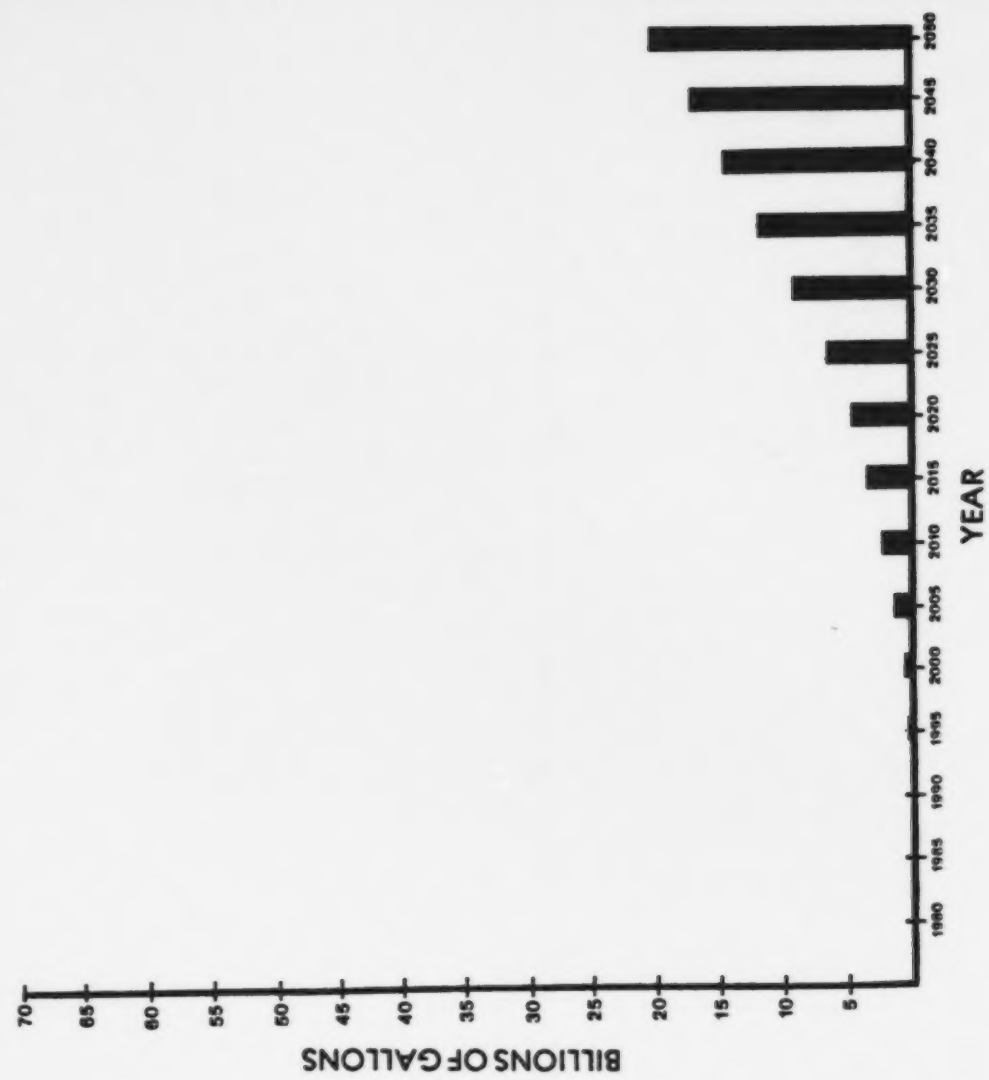


Figure 21. Magnitude of yearly deficits (1932 river flow).

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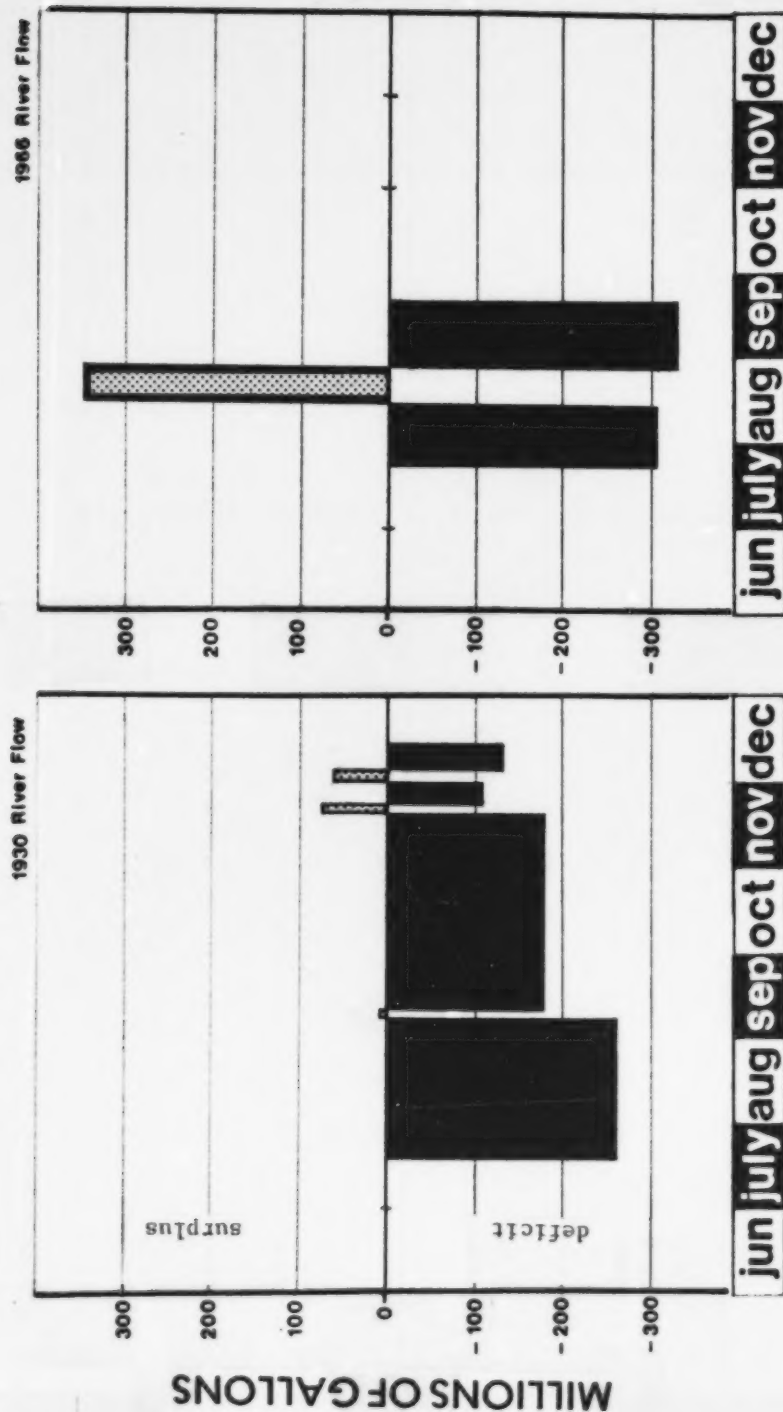


Figure 22. Location of deficits in time (2030 demand).

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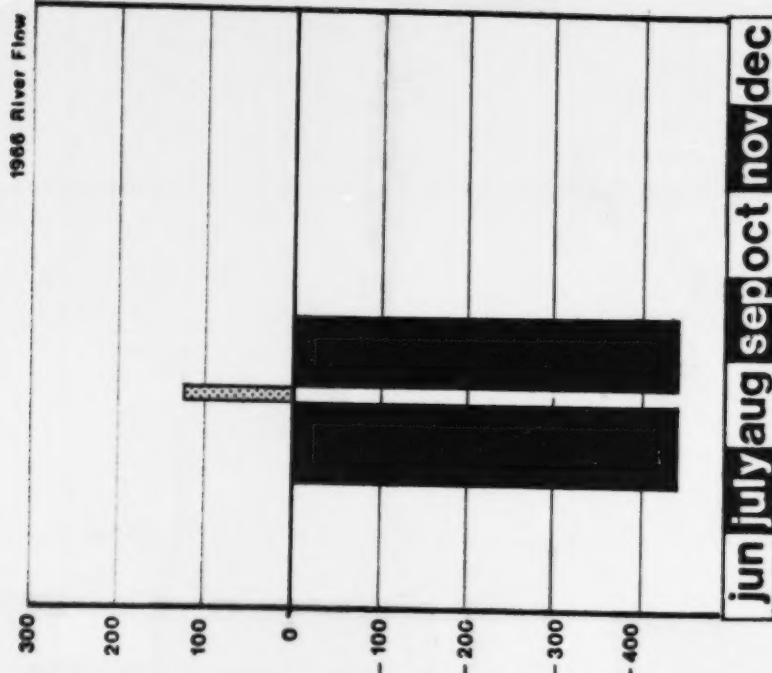
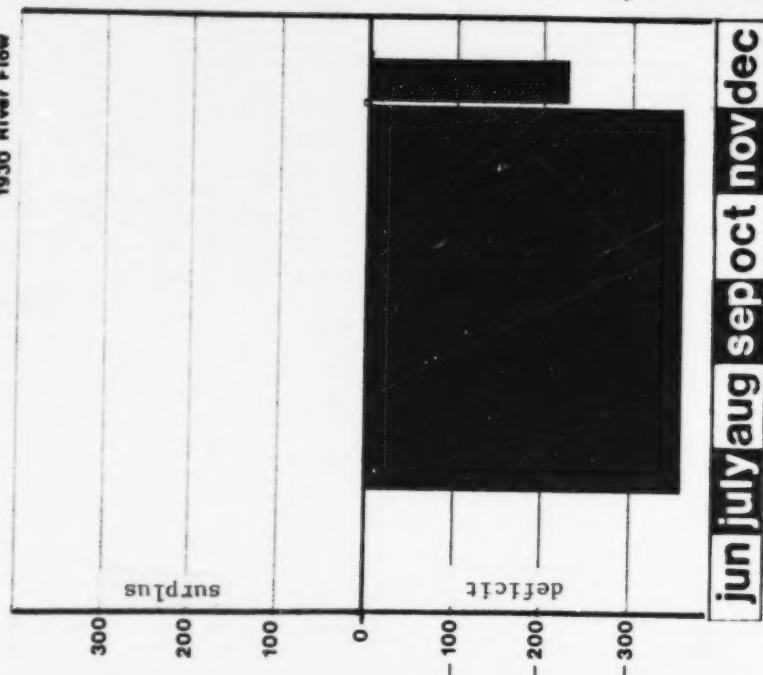


Figure 23. Location of deficits in time (2050 demand).

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analysis therefore also reveals important information about the kind of water shortages that might occur in the WMA. These deficit patterns may have an impact on the kind of solution which might be tried to alleviate shortages in the WMA.

Based on this analysis and assuming constant per capita use and the projected population growth, it is reasonable to expect that water shortages will occur over time and with increasing frequency. They may or may not be of sufficient size or duration to warrant immediate action. If they are severe, however, the types of facilities designed to meet them may be critical. For example, some deficits may require that large quantities of water be available for short periods of time, while other deficit patterns will be satisfied by smaller quantities of water available over longer periods of time.

The previous analysis has dealt with totally unregulated Potomac flow. Fortunately, action has been taken to forestall immediate water shortages by construction of the Bloomington Reservoir, the effect of which is discussed in the following section.

EFFECT OF THE BLOOMINGTON RESERVOIR ON DEFICIT FLOW

The Bloomington Reservoir, located on the north fork of the Potomac near Bloomington, Maryland, is scheduled for completion in 1980, and to begin releasing water in 1981.(28) The flow regulating properties of this reservoir will have a significant effect on water availability during low flow periods in the WMA. Based on COE assumptions, it can release a flow of 135 MGD into the Potomac for 120 continuous days. To illustrate the effect that the Bloomington Reservoir will have on alleviating water shortage problems in the WMA, the release patterns shown in Table 14 have been assumed; using COE's release patterns, the deficit analysis in the previous section was redone.

TABLE 14. POTOMAC FLOW AUGMENTATION (Corps of Engineers)

Bloomington Reservoir planned release*	
Month	Quantity (MGD)
July	60
August	135
September	135
October	135
November	75

* plus 2-days storage in existing water systems.

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Figure 24 shows the projected deficits for 2030 and 2050 demand versus historic river flows. A comparison of Figure 24 with Figure 16 immediately illustrates that the Bloomington Reservoir will greatly reduce the number and potential severity of deficits in the WMA. Figures 25, 26, and 27 show the effect that the Bloomington Reservoir will have on the magnitude and frequency of deficits over time, assuming 1930, 1966, and 1932 river flow conditions.

The availability of water from the Bloomington Reservoir will obviously reduce the potential severity of the short- and long-term water supply shortages in the WMA. But as shown in Figures 24, 25, 26, and 27, significant deficits may still occur, and as population and demand grow, the probability of a deficit condition increases. Construction of the Bloomington Reservoir has probably delayed these occurrences until a later stage in the planning period. It is therefore useful to examine the options available for augmenting water supply in the WMA. Some of these options are summarized briefly in the following sections and in more detail in the following chapter.

Reservoirs and In-System Storage

The addition of the Bloomington Reservoir and assumption of a 2-day in-line storage capacity markedly reduce the probability of water supply shortages in the WMA. A two-day in-system storage implies that the intake pumps could be shut down for two days before the finished water reservoirs run dry. Discounting the occurrence of the 1930, 1966, and 1932 flow conditions, this strategy effectively solves the problem through 2030. Increasing the in-system storage capacity would also have a positive effect on reducing potential deficits. An additional reservoir combined with more in-system storage would probably solve the deficit problem for any reasonable planning period.

Interconnections

The Interstate Commission on the Potomac has suggested that the Patuxent and Occoquan Reservoirs be used as holding reservoirs during high flow periods, to be discharged during low flow periods. The reservoirs would be operated so that they would always be filled to maximum capacity at the beginning of the Potomac low flow period. Such an approach would require extensive construction of pumping and transmission facilities.(29)

Renovated Wastewater

It has been suggested that construction of renovated wastewater facilities would help to alleviate not only water supply shortage problems but waste disposal problems as well. The proposed Dickerson plant would have fallen into this category. The advantage of this approach is that renovated wastewater plants could be constructed when and where needed.(30)

Conservation

Another strategy that might be applied to relieve water supply shortages in the WMA is conservation. Conservation could take the form of

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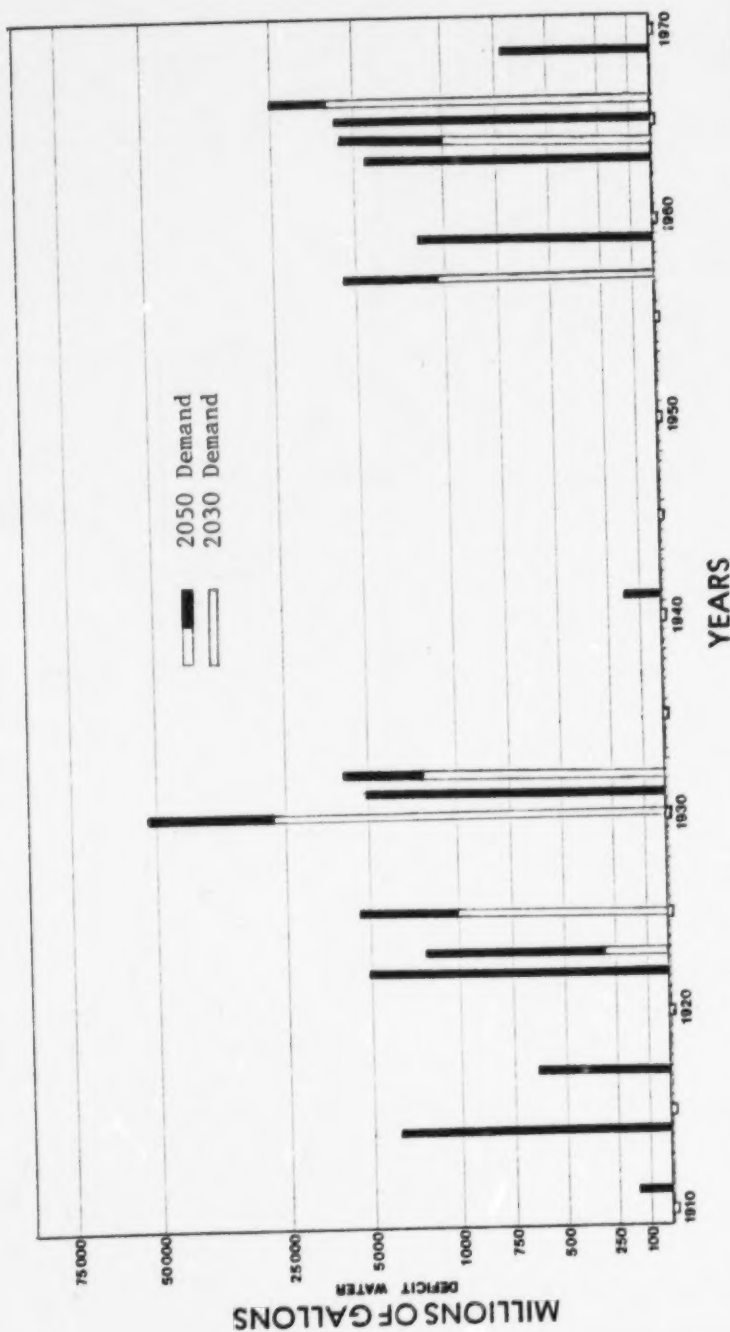


Figure 24. Deficit analysis with Bloomington Reservoir on line (2030 and 2050 demand).

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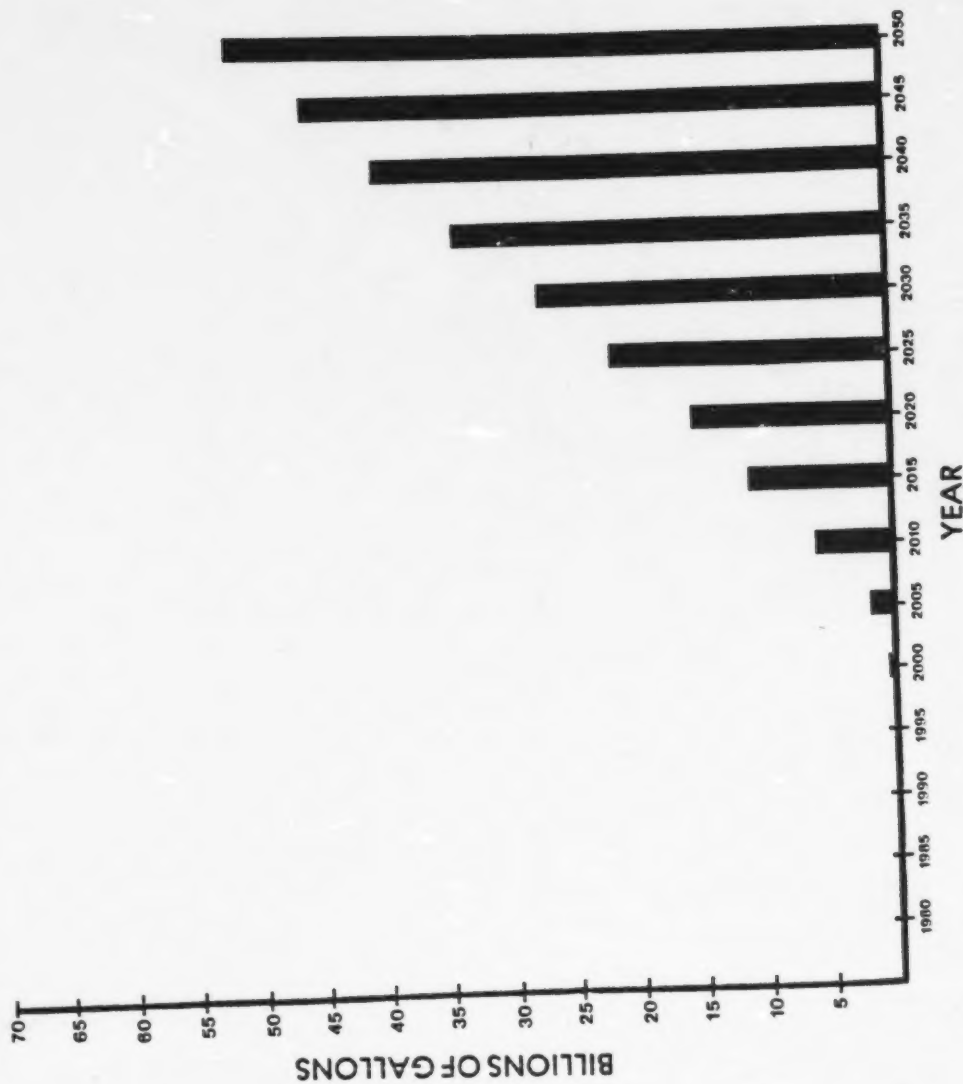


Figure 25. Magnitude of yearly deficits with Bloomington Reservoir on line (1930 river flow).

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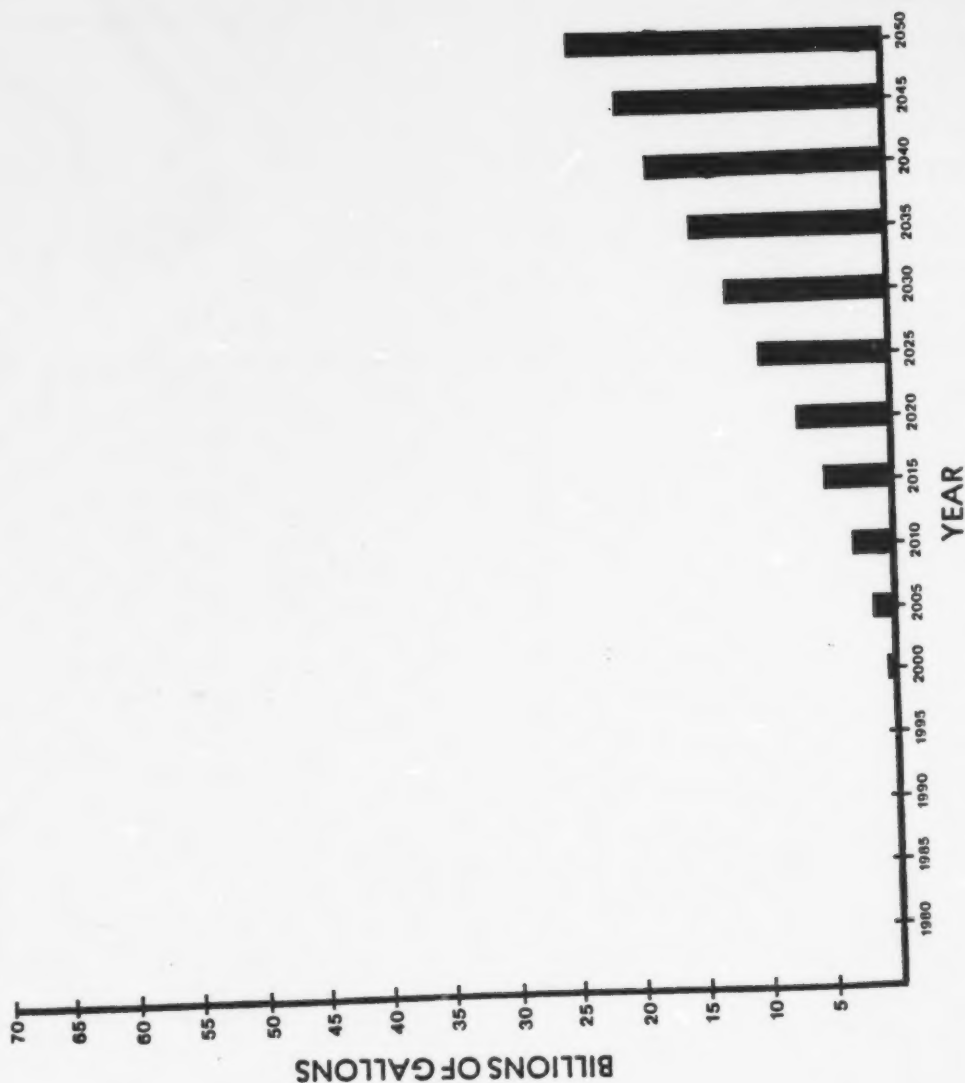


Figure 26. Magnitude of yearly deficits with Bloomington Reservoir on line (1966 river flow).

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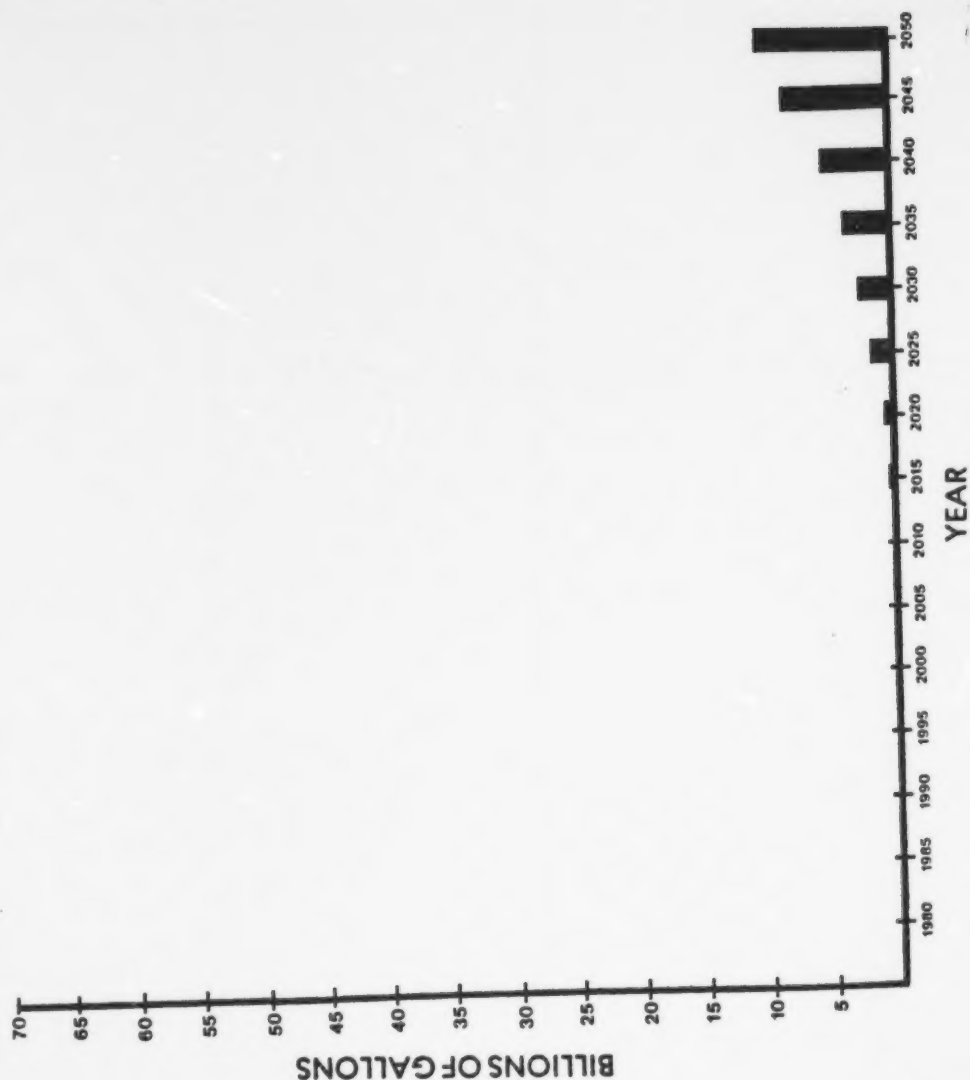
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Figure 27. Magnitude of yearly deficits with Bloomington Reservoir on line (1932 river flow).

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mandated immediate water use reduction or installation of flow reducing devices in new and existing homes.(31)

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SECTION 7

ANALYSIS OF AUGMENTATION OPTIONS

In this section, the options discussed in the previous section will be examined in more detail. The following analysis will be based on a standard set of flow and demand conditions which assume that the Bloomington reservoir is in full operation. These conditions are the total and maximum deficits for the 1930, 1966, and 1932 flow conditions, assuming the constant per capita demand scenario.

Total deficit is the accumulated amount of water that is required when the demand for water is greater than the available supply. Maximum deficit is the amount of water, on a daily basis, required to meet the worst deficit period of more than seven days duration. It was assumed that emergency measures could resolve the extreme conditions for seven days. Table 15 shows projected deficits based on the assumed conditions. As can be seen, the total amounts required differ significantly, ranging from 52,577 million gallons under 1930 flow conditions to 11,193 million gallons under 1932 river flows. Table 16 shows the estimated peak deficit during a given year.

RESERVOIR AND STORAGE SOLUTION

Reservoir construction has been proposed as one means of solving the WMA water shortage problem. Figure 28 shows the river system that serves the WMA and the locations of reservoir sites used in this analysis. Table 17 lists the names of the possible reservoirs, their design capacity, initial cost of construction, monthly standby costs, and monthly O&M cost. (32) A computer program was developed to sort out water supply alternative conditions shown in Tables 15 and 16, and is described in Appendix D. Figure 29 shows the deficits resulting from the three flow conditions over time. The step functions show the available capacities resulting from the construction of Verona, Sixes Bridge, and Catoctin Reservoirs. It should be noted that as of this report the Catoctin reservoir has not been authorized for study. Except for the most severe conditions, the Verona Reservoir would easily solve water deficit problems through 2050. As an alternative, it is worthwhile to examine briefly some of the possibilities resulting from changing the release pattern shown in Table 14.

Alternate Discharge Pattern

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The discharge pattern shown in Table 14 is planned for low flow conditions; however, if the discharge pattern could be modified instantaneously to reflect the river flow conditions, the Bloomington capacity

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TABLE 15. PROJECTED TOTAL DEFICITS (mil gal/year)

Year	Based on 1930	Based on 1966	Based on 1932
	river flow	river flow	river flow
2000	189.1	623.9	0
2005	2,093.1	2,089.4	0
2010	6,463.3	3,771.9	0
2015	11,393.8	5,646.9	188.2
2020	15,840.7	7,425.1	857.0
2025	22,388.7	10,272.6	1,874.1
2030	27,781.4	12,602.6	2,707.1
2035	34,559.0	15,646.6	4,158.3
2040	40,665.0	18,711.6	6,032.5
2045	46,582.0	21,878.0	8,449.4
2050	52,576.9	25,074.9	11,193.4

Note: Total deficit accumulation when supply does not meet demand during the specified year.

TABLE 16. MAXIMUM DEFICIT (MGD)

Year	Based on 1930	Based on 1966	Based on 1932
	river flow	river flow	river flow
2000	54.0	119.0	0
2005	114.3	155.8	0
2010	116.0	204.8	0
2015	150.7	242.4	90.5
2020	185.9	254.0	146.0
2025	236.3	279.9	156.2
2030	268.1	330.6	193.4
2035	260.2	368.7	245.2
2040	298.7	385.5	290.9
2045	324.9	426.6	311.8
2050	363.2	447.9	361.5

Note: Maximum deficit of greater than 7 days duration that occurred during the year indicated.

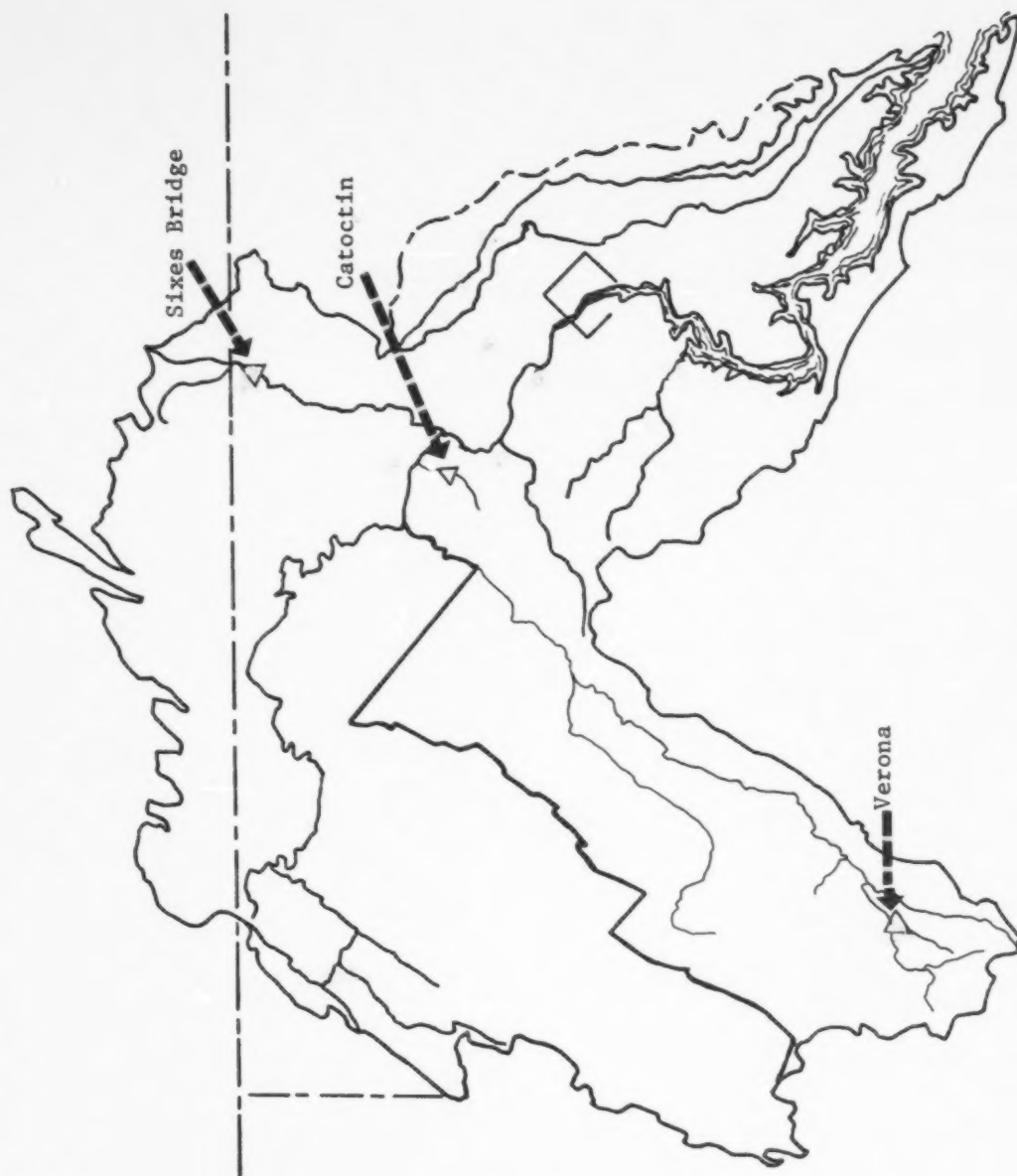


Figure 28. Reservoir sites within the WMA river system.

TABLE 17. RESERVOIR COSTS

Reservoirs	Design capacity MGD	Cost* of construction	Monthly standby cost	Monthly O&M cost at capacity
Verona	190	48,395,351	7,638	0
Sixes Bridge	90	36,828,142	3,032	0
Catoctin	145	35,054,413	18,742	74,722**

* All cost in 1976 dollars; ENR= 2430

** Influent pumping.

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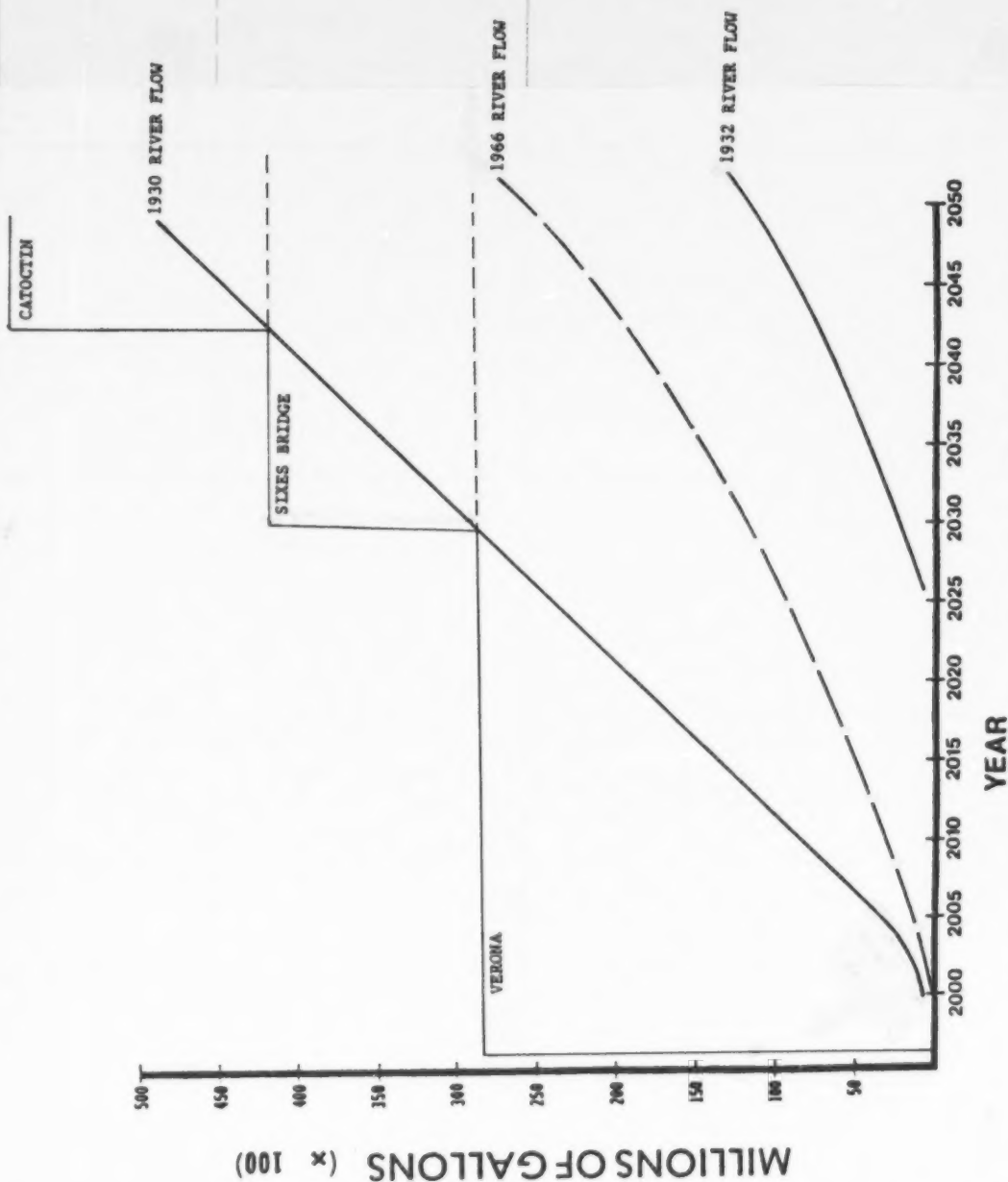


Figure 29. Reservoir solution schedule of development.

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could be used even more efficiently, thereby delaying any future construction. Unfortunately, coordinating release patterns at Bloomington with flow conditions at a point 30 days in travel time downstream is not easy. It might be possible with additional study to monitor, through the use of simulation models and an early warning alert system, the levels of flow to demand conditions. Such an effort would appear worthwhile in this case. Perhaps additional water beyond that normally designated for water supply could also be released under extreme low flow conditions.

Hypothetically, if the releases from Bloomington could be timed to low flow conditions in the WMA, the effect of Bloomington release patterns on the construction date for the first new reservoir would be as shown in Table 18.

TABLE 18. EFFECT OF ALTERNATE RELEASE DATE

Release patterns	Year additional alternative required		
	Based on 1930 river flow	Based on 1966 river flow	Based on 1932 river flow
Planned release pattern	1996	1996	2011
Optimal release pattern	2003	2020	2035

As demonstrated in Table 18, an optimal release pattern under moderately severe low flow conditions (1932 flow) could delay reservoir construction from 2011 to 2035. Figure 30 illustrates the effect of optimal release. Optimal release occurs when the actual amount of deficit water is released from the reservoir at the proper time so that the released water is at the water utility intake when needed to supplement the amount of supply water that would have been available if the release had not occurred. This is difficult to achieve, but a compromise release pattern somewhere between the planned and optimal pattern should be possible. The optimal release pattern reservoir construction date occurs at the intersection of the horizontal line with the deficit lines in Figure 30.

RENOVATED WASTEWATER

Renovated wastewater could conceivably be used to augment water supply in the Potomac River. If the renovated wastewater (RWV) facilities are built solely for the purpose of providing deficit water, their entire cost should be charged against water supply. If, however, they serve the dual purpose of supplying deficit water and of purifying wastewater, a portion of the cost should be allocated to each function. For example, the WMA may need additional wastewater treatment capacity and may use the effluent to help solve the water supply deficit problem. In accomplishing

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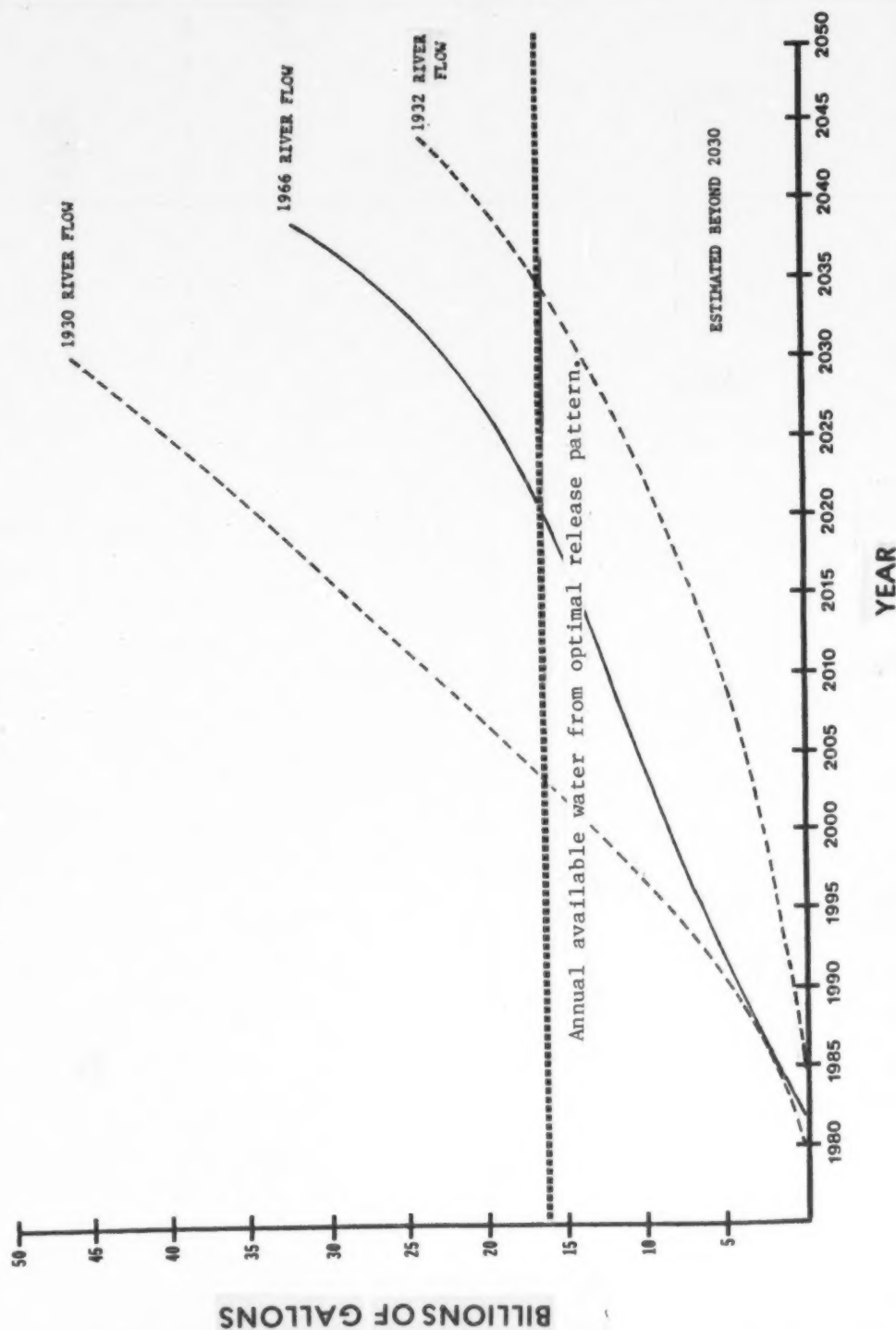


Figure 30. Effect of optimal release pattern for Bloomington Reservoir.

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both goals, it would be necessary to treat the wastewater to a higher level than normal. All costs for normal wastewater treatment should be charged to wastewater processing, while all incremental costs for treating wastewater to drinking water level should be charged to water supply. This procedure is used in the following analysis. Figure 31 shows the locations of potential RWW plant sites.

For this analysis, the ratio of the Blue Plains waste treatment cost to the RWW cost was used to allocate costs to water supply and waste treatment. Based on the Blue Plains costs, it was determined that 60 percent of the total cost incurred is associated with wastewater treatment and 40 percent is associated with renovated wastewater. Table 19 shows the design capacity, construction costs, monthly standby cost, and monthly O&M cost for the renovated wastewater portion of the treatment facilities. O&M and capital costs were obtained initially from the NEWS report and were modified to reflect the assumptions for this study.(33) Annual capital costs were obtained by depreciating construction cost at 6 percent. It was assumed that the waste treatment plant would be operating at full capacity in the year of construction.

Obviously, a cost allocation other than 40 percent for water supply and 60 percent for wastewater treatment could be used. For example, water quality conditions in the Potomac estuary may dictate wastewater treatment in excess of that existing at the Blue Plains facility. This increased treatment level would change the ratio of the cost being allocated for wastewater treatment and would make RWW a more attractive alternative, from a cost standpoint, for new source water. However, in order for the RWW cost allocated for water supply purposes to equal the cost of supplying the same water by reservoirs, 92.8 percent of the total cost would have to be allocated against wastewater treatment.

In sizing the RWW facilities to meet deficit requirements, two factors were considered: first, the magnitude of the deficit, and second, the time span during which the deficit occurs. Examination of the magnitude of the deficit for the river flow years of 1930, 1966, and 1932 reveals that the amount of the deficit is clearly larger for the river flow conditions of 1930 than for those of 1966. However, the severity of the deficit from a peak flow standpoint (MGD) was greater under 1966 conditions.

In selecting RWW plants to meet the deficit condition, the controlling factor became the daily requirements for water during the deficit period rather than the total magnitude of the deficit. For example, a deficit of 1,000 mil gal of water may occur in a 10-day time period. This means that, on an average, 100 MGD are required during each day of the deficit. This generates the requirement for a renovated wastewater facility with a 100 MGD capacity in order to meet the deficit requirements for a 10-day time period. A 2.75 MGD facility would supply the 1,000 mil gal of water over a 1-year time period but would have had little effect during the deficit water period.

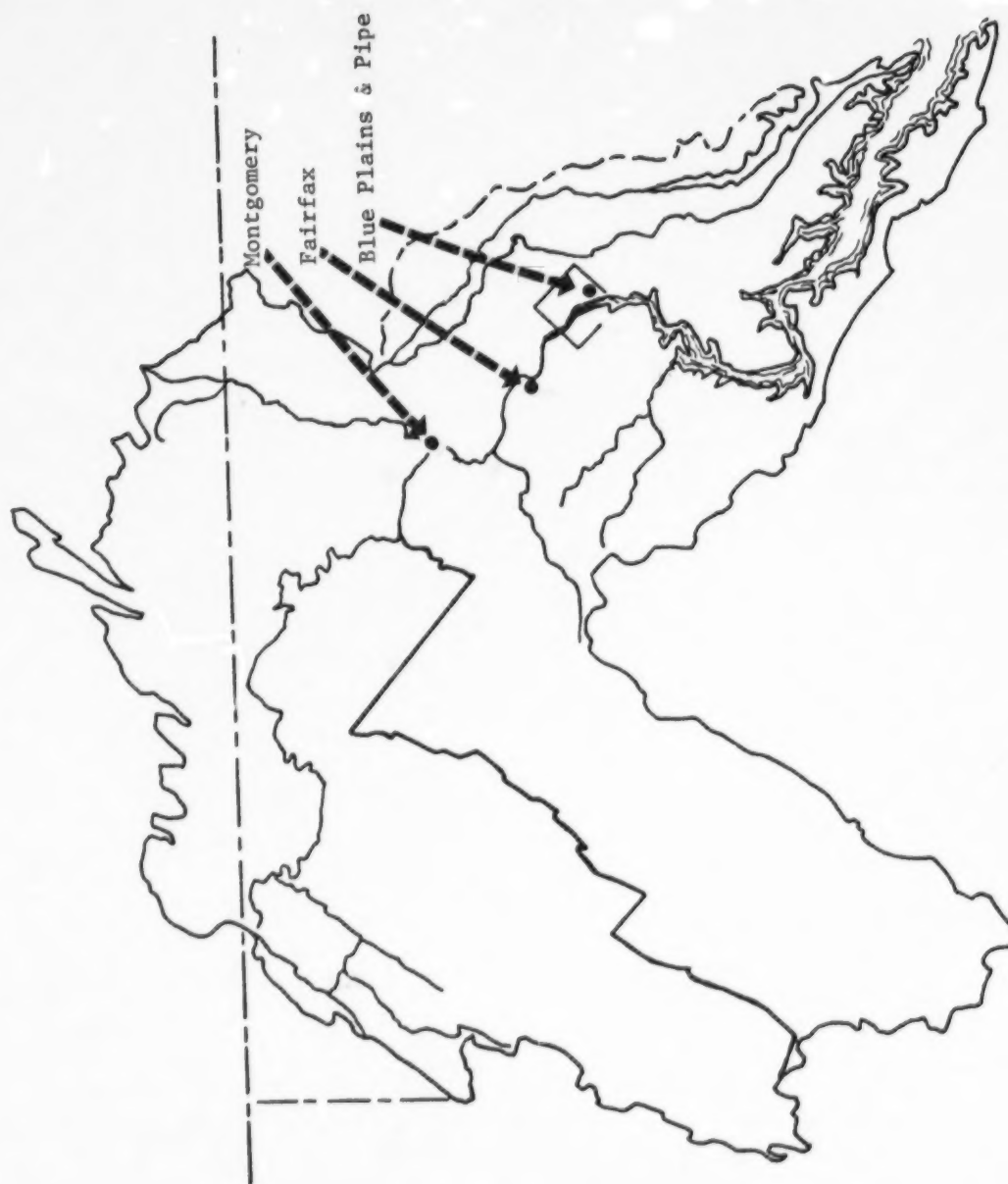


Figure 31. RWW facilities within the WMA river system.

TABLE 19. RENOVATED WASTEWATER

Facility	Design capacity MGD	Cost of construction \$	Monthly standby cost \$	Monthly O&M cost at capacity \$
Blue Plains and pipe	200	309,375,988	148,832	1,114,705
Montgomery	75	164,535,372	55,123	624,725
Montgomery added	75	151,477,398	55,123	624,725
Fairfax	35	141,089,817	29,399	330,737
Fairfax added	35	75,790,147	35,523	324,612

* All cost in 1976 dollars; ENR = 2430.

Obviously, RWW facilities in conjunction with storage would reduce the capacity requirements of RWW facilities in order to meet the specific deficit requirements. However, storage requirements are great and reservoirs may be difficult to locate near the RWW facilities. Therefore, for the purpose of this analysis, no storage facilities were used, and all RWW facilities were constructed to meet peak deficits greater than 7 days. It was assumed that deficits of less than 7 days but exceeding the capacity of the RWW facilities would be handled by emergency measures. By examining the amount and duration of each peak deficit, the peak flow requirement for the largest deficit condition for each river flow condition could be identified and graphed.

Figures 32 through 34 show how RWW will meet the deficit requirement. For example, Figure 32 shows that, for the 1930 flow condition, the first Blue Plains plant plus pipe transport at a capacity of 200 MGD will solve the problem from the time the first deficit occurs in 1995 until the year 2020, when a new facility will have to be built. These same relationships are shown for the 1966 and 1932 flow conditions in Figures 33 and 34. It should be noted that the actual water provided on a year-round basis far exceeds the deficit requirement. However, the RWW facilities are selected to meet the specific peak deficit requirements resulting from the river flow.

INTERCONNECTIONS

Interconnections are pipes with pumps that can transport, when needed, excess water from the Potomac to the Patuxent and Occoquan reservoirs and then back to the water treatment plant located on the Potomac. Reservoirs are assumed filled to capacity prior to low flow and are then drawn down as needed during periods of excess demand. Figure 35 shows the reservoir locations and a schematic diagram of the interconnections.

Because the Potomac River flow varies significantly each year and deficit water conditions occur only occasionally, it is difficult to identify the specific amount of water that must be pumped into the reservoir and back to the treatment plants each year. For some years water far in excess of that needed will be pumped into the reservoirs and will ultimately be spilled. In some years, if the reservoirs are full, no water will be pumped at all. For purposes of this analysis, to facilitate cost comparisons, it was assumed that the amount of water pumped equals the amount of deficit water in the year of analysis. This amount will, in turn, depend upon the flow condition assumed and the demand for a given year. The system must be able to satisfy this level of deficit whether the deficit occurs or not. Operationally, the water will have to be pumped into the reservoir in anticipation of a deficit so that a cost will incur no matter whether the water is used or not. For example, assuming the 1930 flow and 2050 demand, the amount of water pumped would be 52,576 mil gal.

Flow conditions will vary from year to year as will demand. Not all

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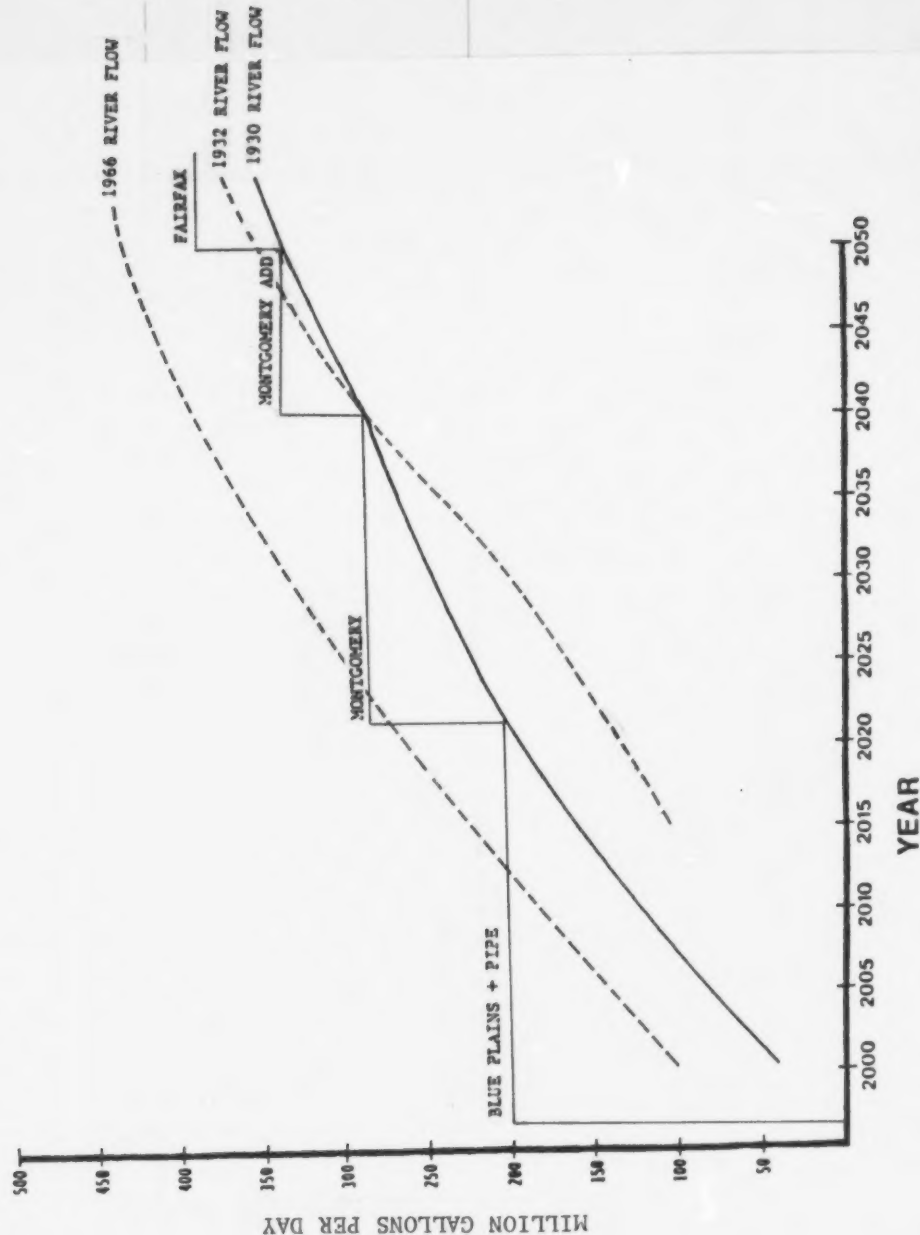


Figure 32. Renovated waste water solution schedule of development (based on 1930 river flow conditions).

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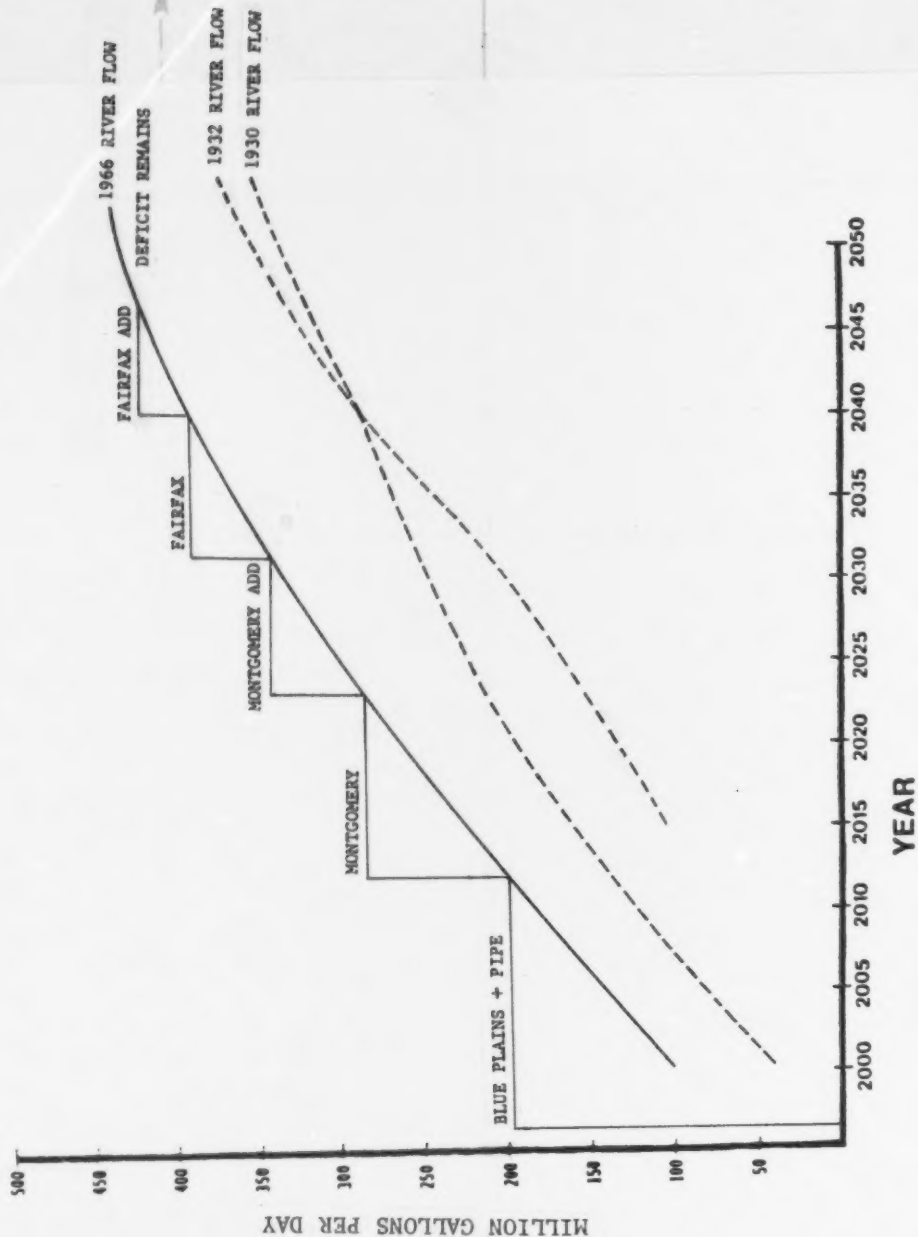
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Renovated waste water solution schedule of development (based on 1966 river flow conditions).

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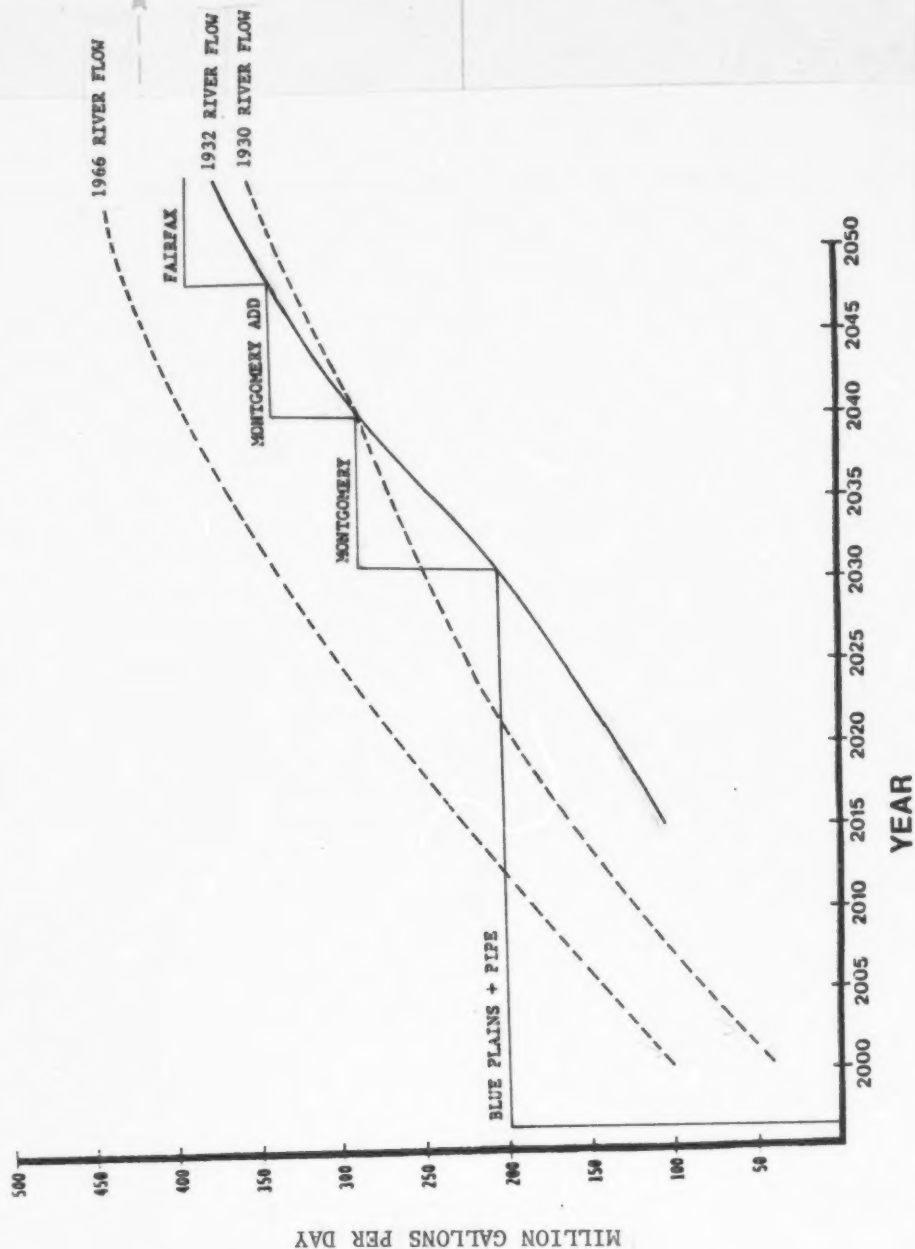


Figure 34. Renovated waste water solution schedule of development (based on 1932 river flow conditions).

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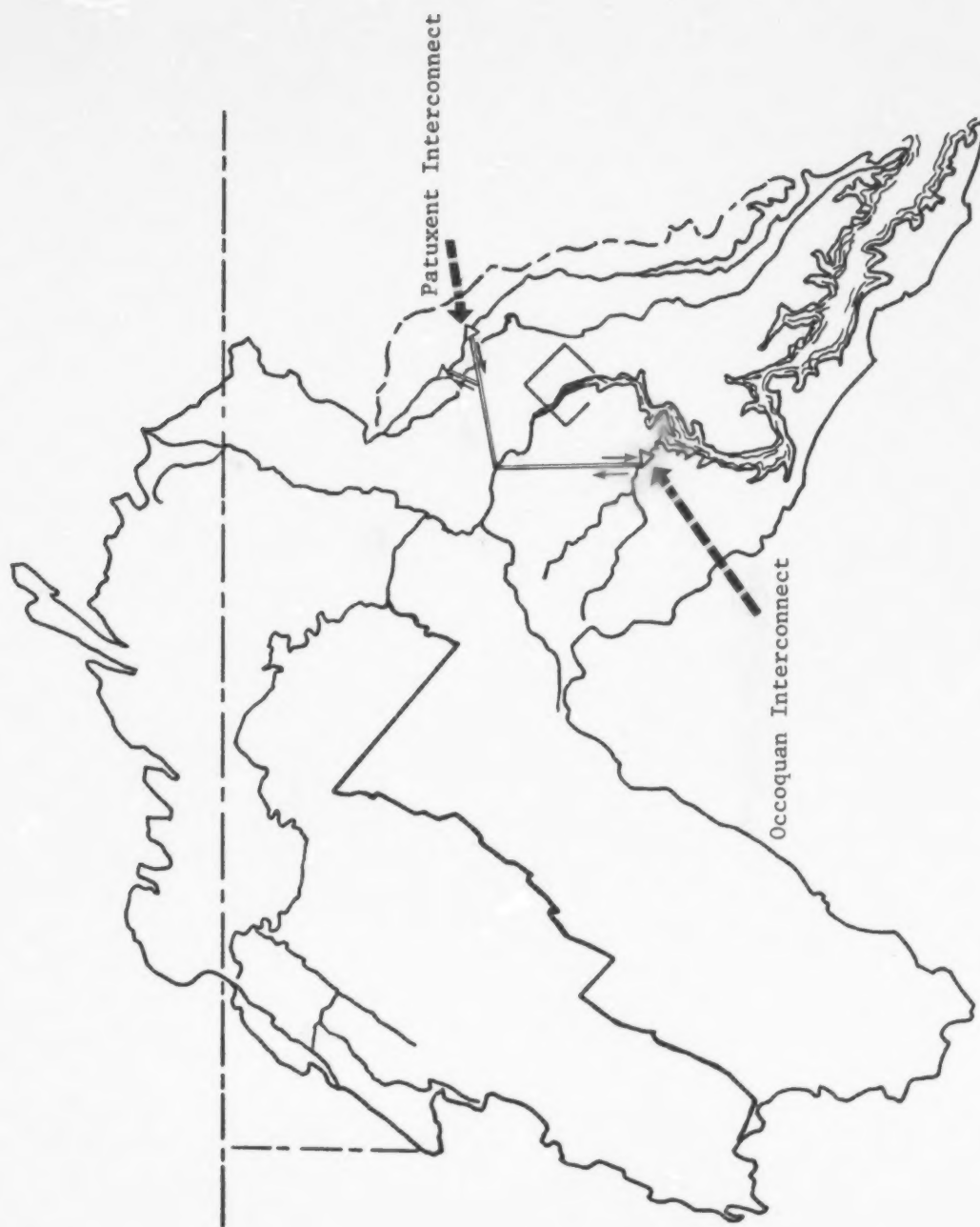


Figure 35. Interconnect concept for the WMA river system.

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of the deficit water will have to be pumped back to the Potomac plants; some will be distributed directly from the reservoir. Therefore, it was assumed in this analysis that the entire deficit was stored and half of the deficit water was pumped back across the service area to be distributed from those treatment plants not located at the reservoir sites. For example, in 2030 (1930 flow) the projected deficit is 27,781 mil gal, all of which is assumed pumped in the reservoirs, and 13,890 mil gal is assumed pumped back across the service zone to be distributed from the water treatment plants.

Because interconnections must be capable of meeting the peak deficits, the same philosophy was used in determining the capacities of the interconnection systems as was used for RWW. There is, however, a constraint that exists in the interconnection system that does not exist with RWW. This constraint deals with the refilling rate of the Patuxent and Occoquan Reservoirs. When the Potomac drops to a deficit condition (low flow), the Occoquan and Patuxent Rivers also drop. If the deficit is severe (1930 flow), the water would be totally drained from both reservoirs and there would not be enough flow from either the Patuxent or Occoquan to supply any additional water.

The two Patuxent reservoirs have a total capacity of 10,100 mil gal and the two Occoquan reservoirs have a total capacity of 9,200 mil gal. It was assumed that the Patuxent treatment plant supplies 43 MGD and the Occoquan plant 65 MGD. Based on historical records, the Patuxent stream flow varied from 0 to 16 MGD during the drought months, while the Occoquan flow varied from 0 to 17 MGD.

Table 20 illustrates the problem of relationships between flow in the Patuxent and Occoquan and flow in the Potomac for 1930. Because this relationship is critical to the success or failure of the interconnection system, further study was conducted on the interrelationship between the flows in the streams. The analysis was not exhaustive, but the results verify the relationship indicated in Table 20. When flows in the Potomac are low, flows in the other streams considered, Patuxent and Occoquan, were also low. This analysis is discussed in detail in Appendix F.

As can be seen in Figure 36, by 2015 the Occoquan and Patuxent Rivers are totally dry and all of the water in the reservoirs has been exhausted. This results in their deficits having to be added to the Potomac deficit which increases the deficit sharply.

Figures 37 and 38 illustrate, respectively, the 1966 and 1932 flow conditions. As shown in Figure 37, the interconnection capacity fails in the year 2040. For the 1932 flow condition (Figure 38) interconnection can supply water well beyond the planning period. Table 21 lists the estimated capital and operating costs for interconnections.(34)

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TABLE 20. SUPPLY (MGD) - Unregulated flows (1930)

Source	July	Aug.	Sept.	Oct.	Nov.	Dec.
Patuxent	0	0	5	16	11	11
Seneca Creek	4	0	3	3	3	3
Goose Creek	11	1	1	1	3	22
Occoquan	3	0	5	0	0	17

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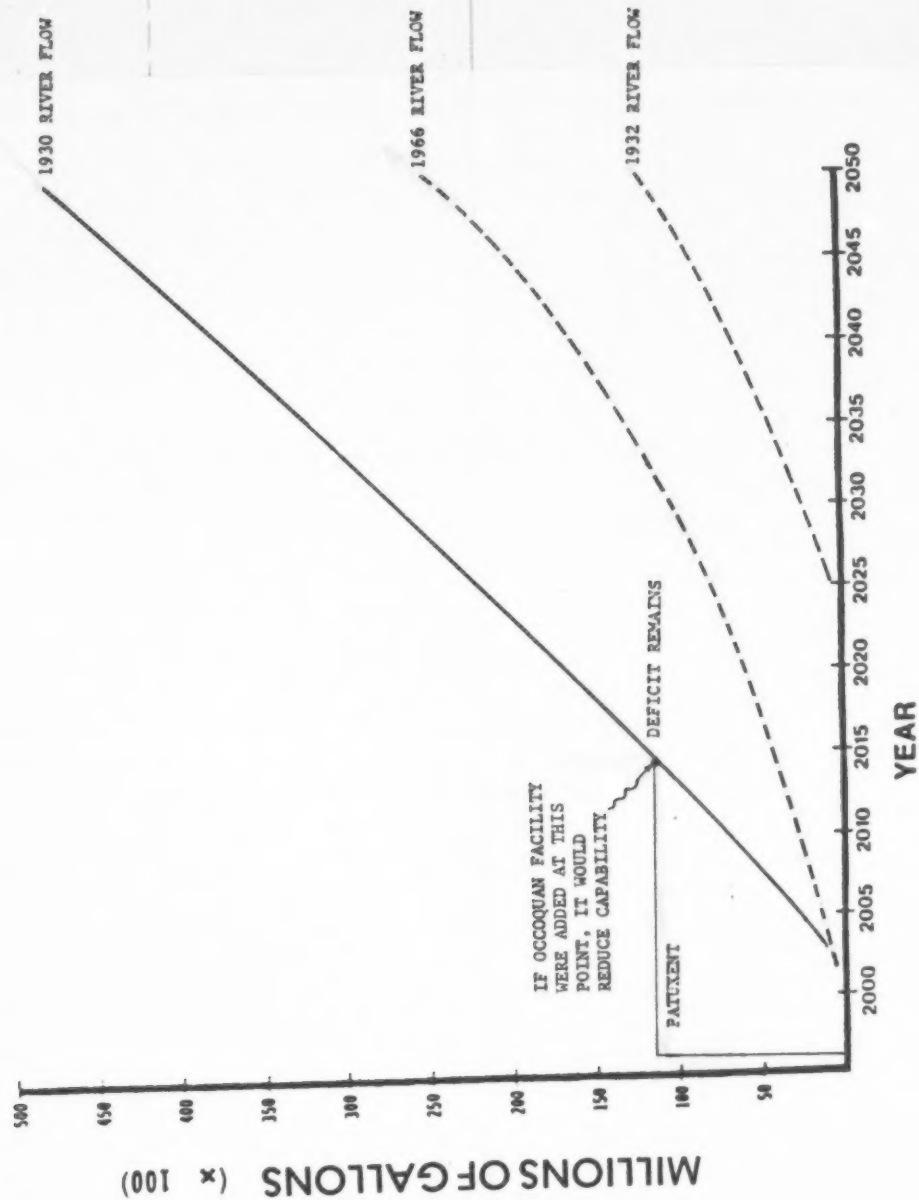


Figure 36. Interconnect solution schedule of development (based on 1930 river flow conditions).

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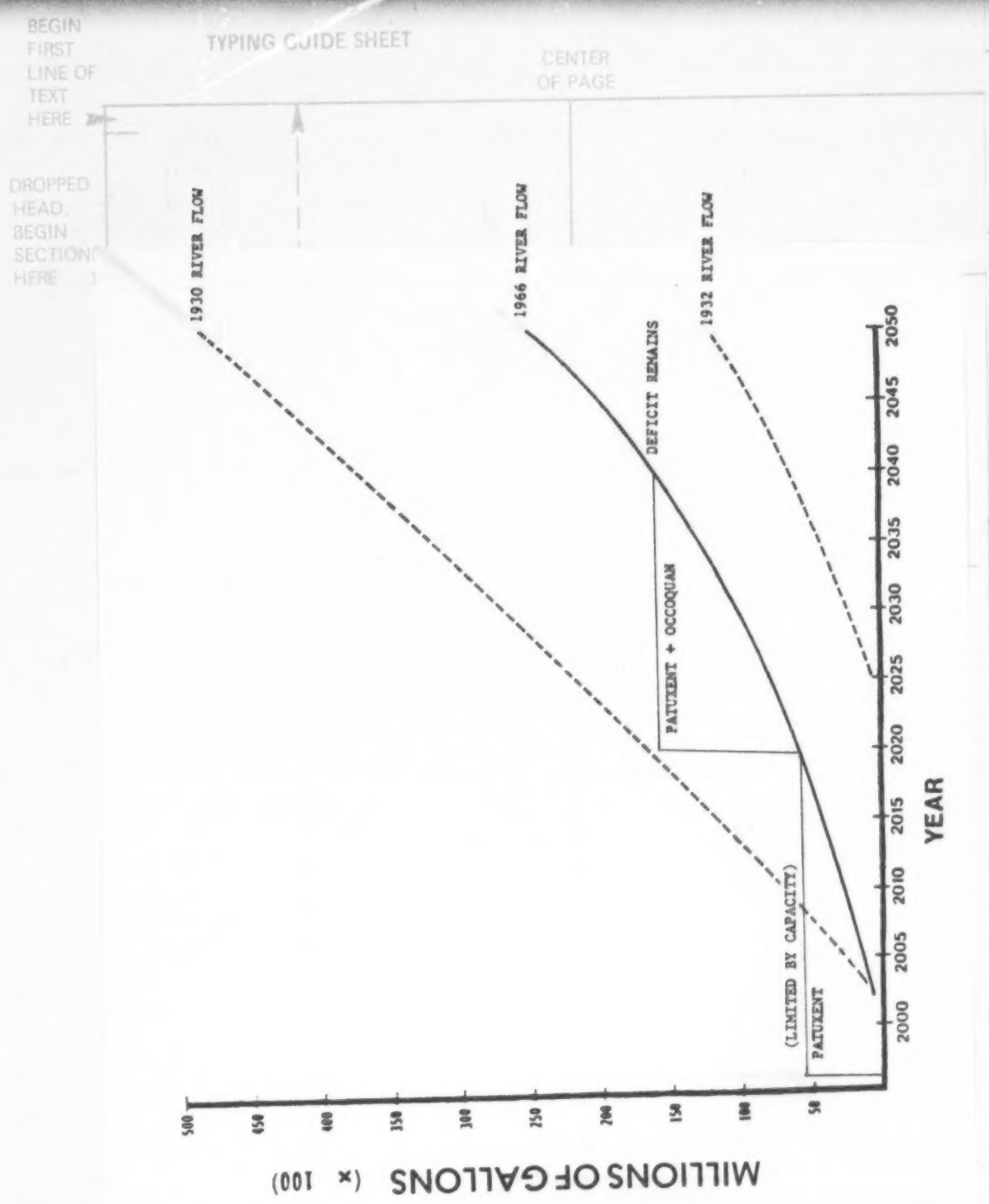


Figure 37. Interconnect solution schedule of development (based on 1966 river flow conditions).

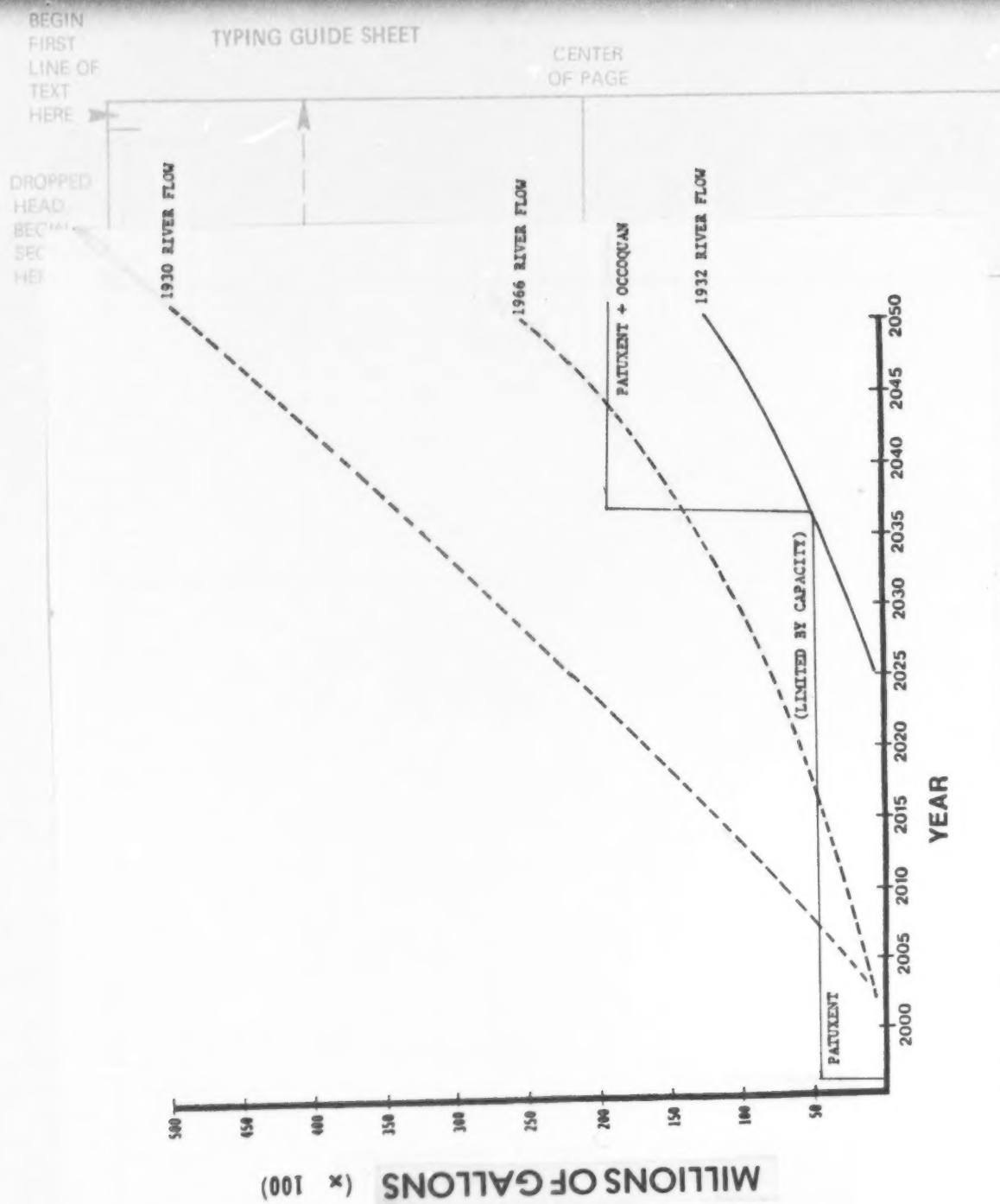


Figure 38. Interconnect solution schedule of development (based on 1932 river flow conditions).

TABLE 21. INTERCONNECTION COSTS

Interconnect	Design capacity MGD	Cost of construction \$	Monthly standby cost \$	Monthly O&M cost at capacity \$
Patuxent	265	176,528,864	139,767	541,428
Occoquan	200	149,040,972	126,170	440,574

* All cost in 1976 dollars; ENR = 2430.

ECONOMIC COMPARISON

In this section, an economic comparison is made between reservoirs, renovated wastewater, and interconnections. The analysis combines the developmental schedules with the cost information shown for the three alternatives. Figures 39 and 40 show the total cumulative and annual costs for the three options for the 1930 flow condition. As can be seen, the reservoir solution is the least expensive. Interconnections cannot meet the total demand over the entire planning period. Figures 41 through 44 show the same costs for the 1966 and 1932 flow condition. In all cases, the reservoir solution is the least expensive option. As can be seen in the Figures, system failures occur with both the renovated wastewater and the interconnection solution. In the case of renovated wastewater due to inability to maintain a 50 percent mix (between renovated and Potomac water assumed for health reasons), and in the case of interconnections due to a lack of raw water.

Another alternative for solving the WMA water shortage problem is conservation. The nature of a conservation strategy is somewhat different than that of the other three alternatives and it is therefore discussed separately.

CONSERVATION

Figure 13 shows the effect of 5 percent reduction per capita consumption on total demand in the WMA. As can be seen, a 5 percent per 10-year period reduction in per capita consumption can substantially reduce total demand for water in the WMA. Figures 45 through 48 illustrate the effect of a conservation program, assuming that the Bloomington Reservoir is on line. The four figures compare the potential deficits with and without conservation for the 1930, 1966, and 1932 river flow conditions for the 2030 and 2050 demands. Conservation has an obvious effect on reducing demand.

Water conservation also has a significant impact on the magnitude of the deficit. Figures 49 and 50 show the effect of conservation on the deficit magnitude, assuming demand scenario 1. Figures 51 and 52 show that in 2050 under 1930 and 1966 flow conditions, the available supply in late August and September is greater than the projected deficit in late July and early August.

Institutionally, conservation has a different impact than the three options discussed earlier. Conservation implies that something is being taken from the consumer instead of being supplied to him. Enforcing conservation is also difficult; in fact, mandating long-term reductions in water use may be impossible. For purposes of this analysis, the focus will be on the long-term per capita reduction of water use based on modifications of the internal plumbing of domestic, commercial, and industrial customers. The approach will be to consider conservation based on replacement of plumbing fittings such as toilets, washing machines, and showers. Hardware such as low-flush toilets, low-flow shower heads, and aeration faucets will be assumed installed in new and existing homes and places of

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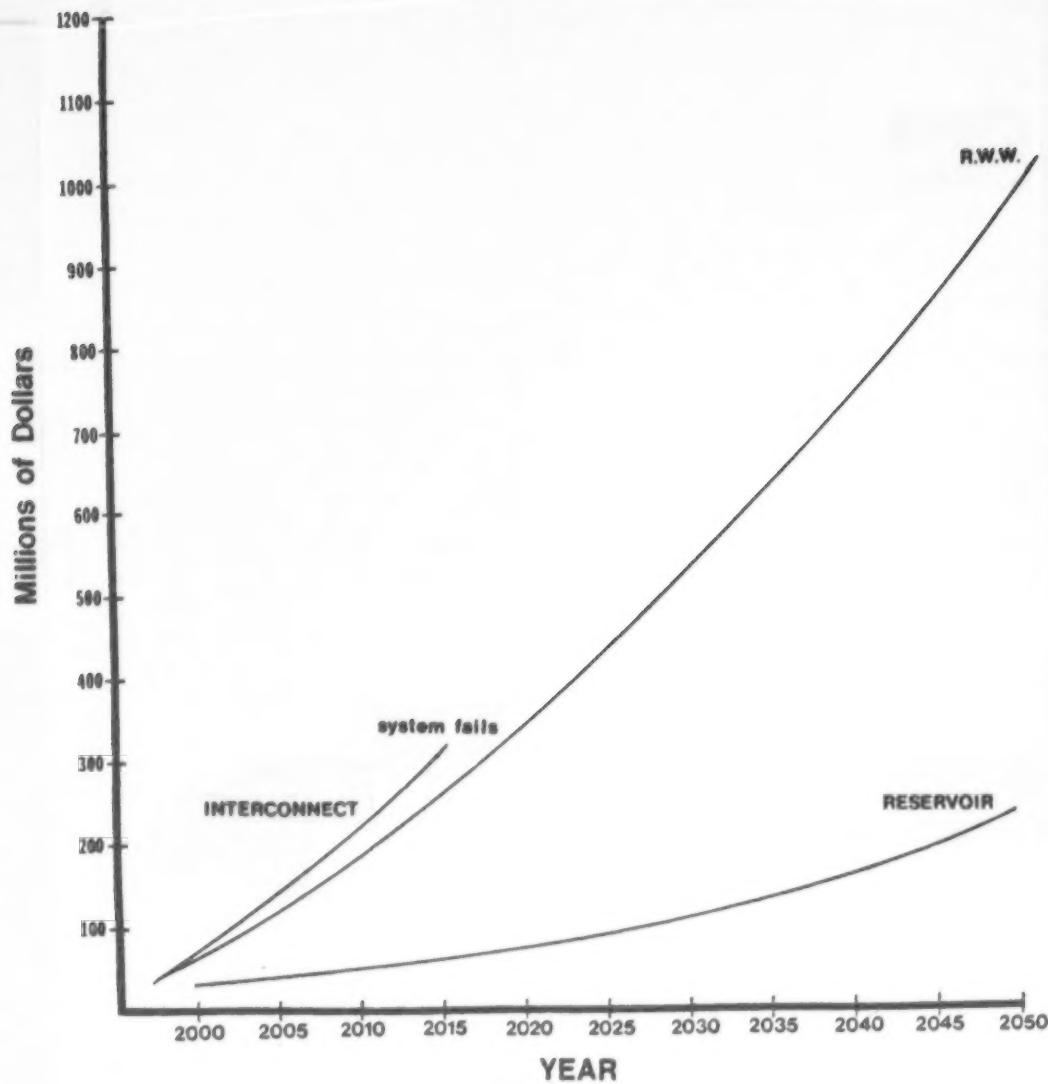
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Figure 39. Cumulative time-investment curve (based on 1930 river flow conditions).

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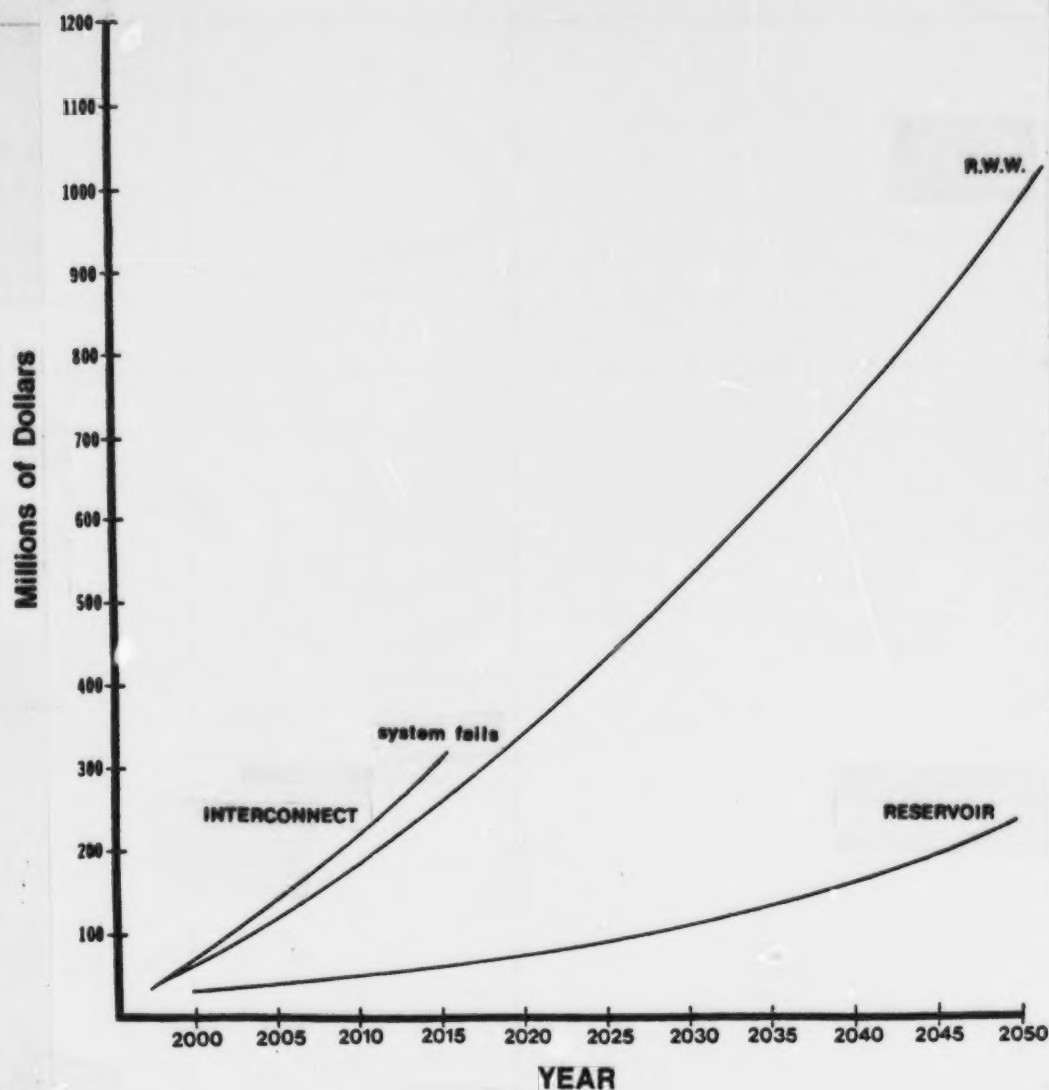
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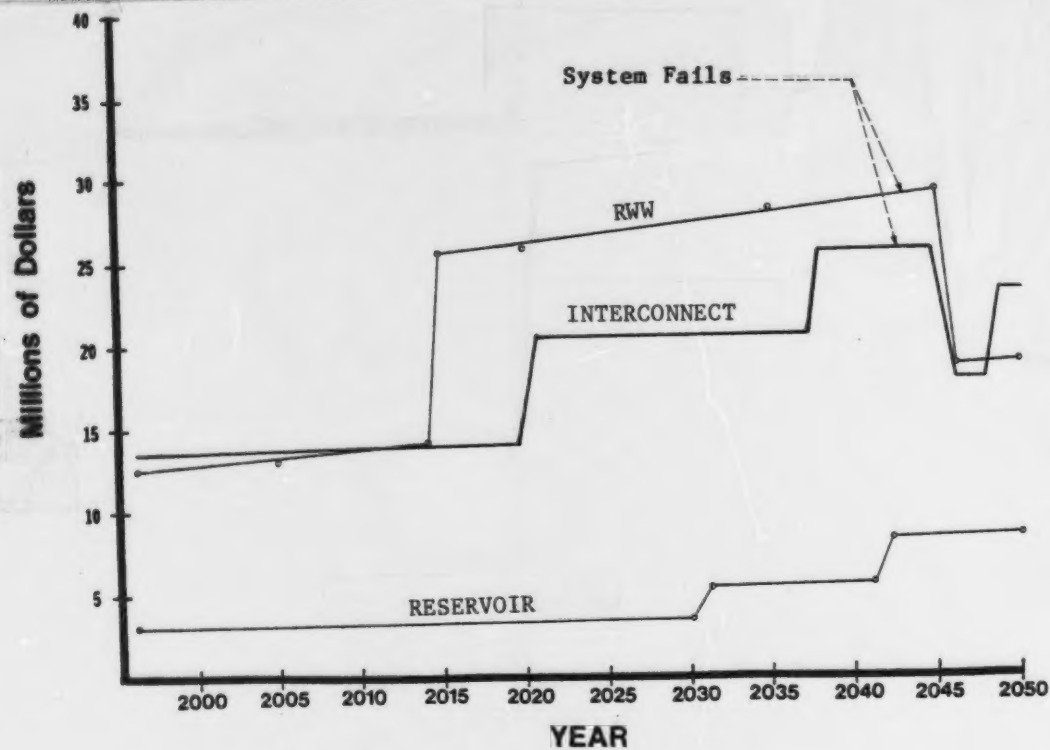
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Figure 40. Time-investment curve (annual cost) (based on 1930 river flow).

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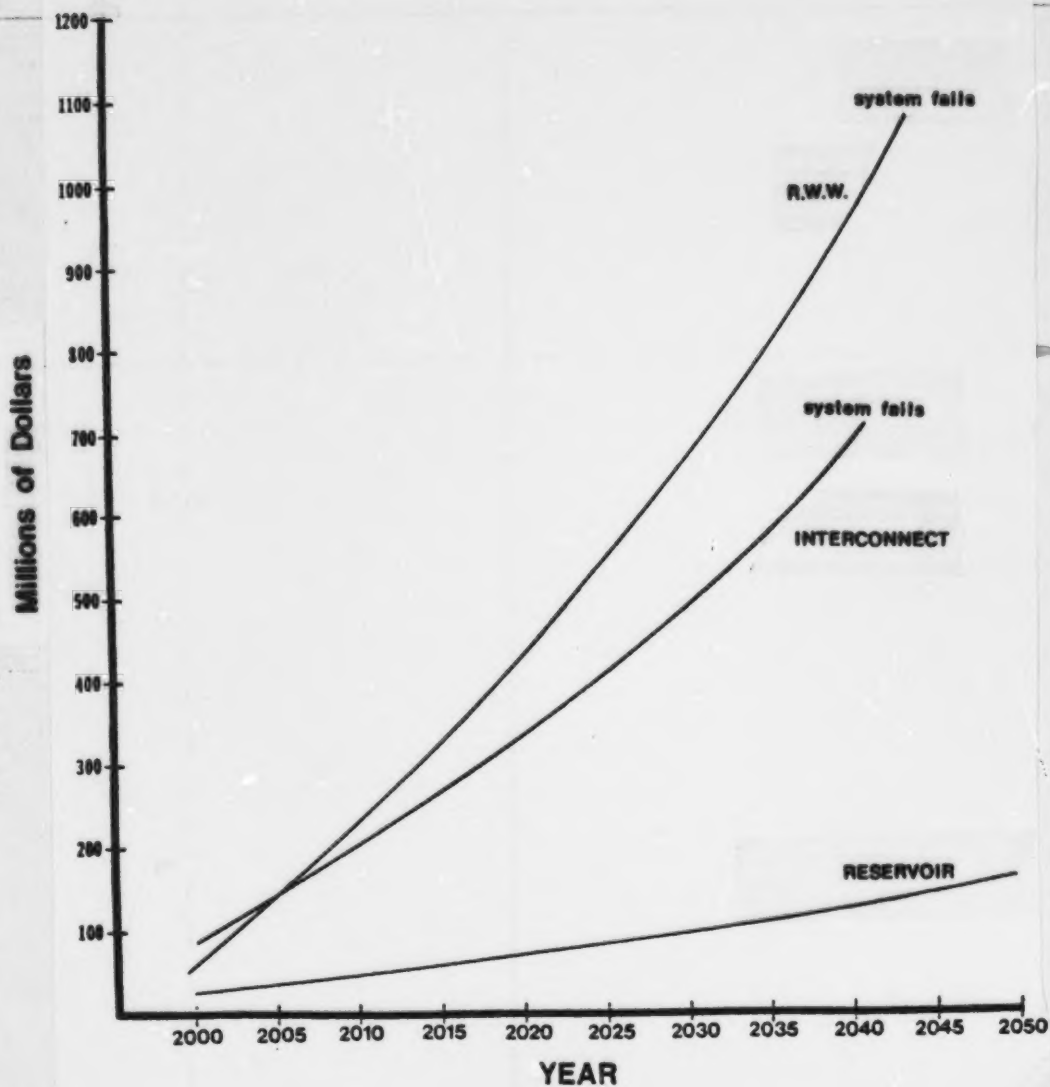
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Figure 41. Cumulative time-investment curve (based on 1966 river flow conditions).

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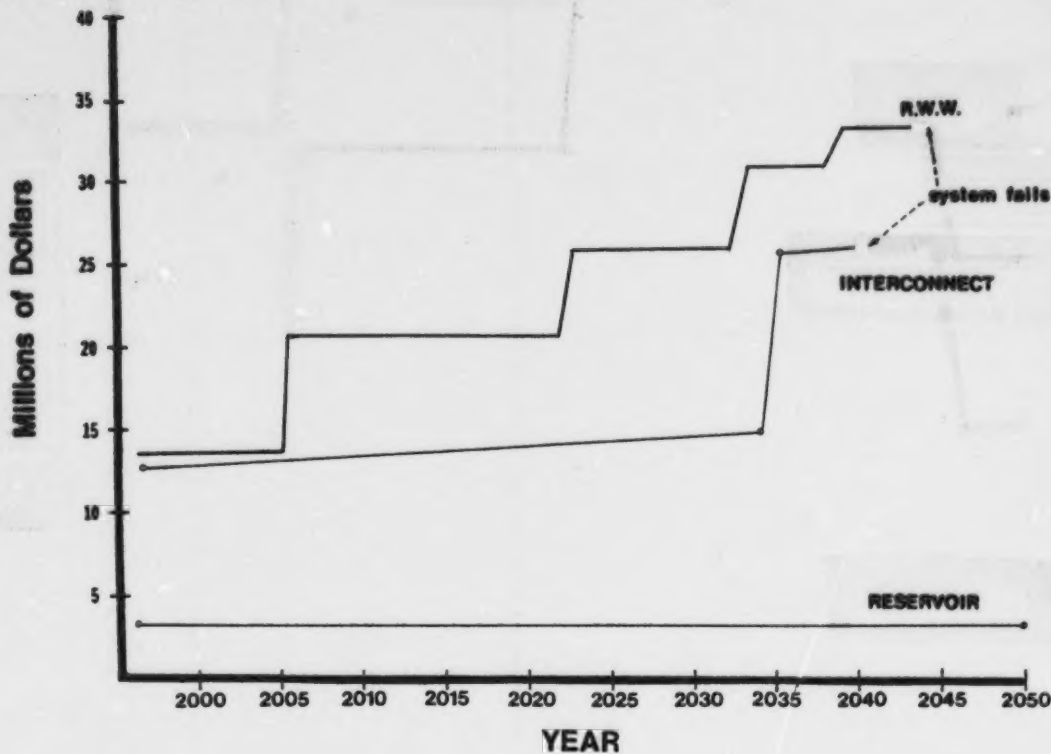
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Figure 42. Time-investment curve (annual cost) (based on 1966 river flow).

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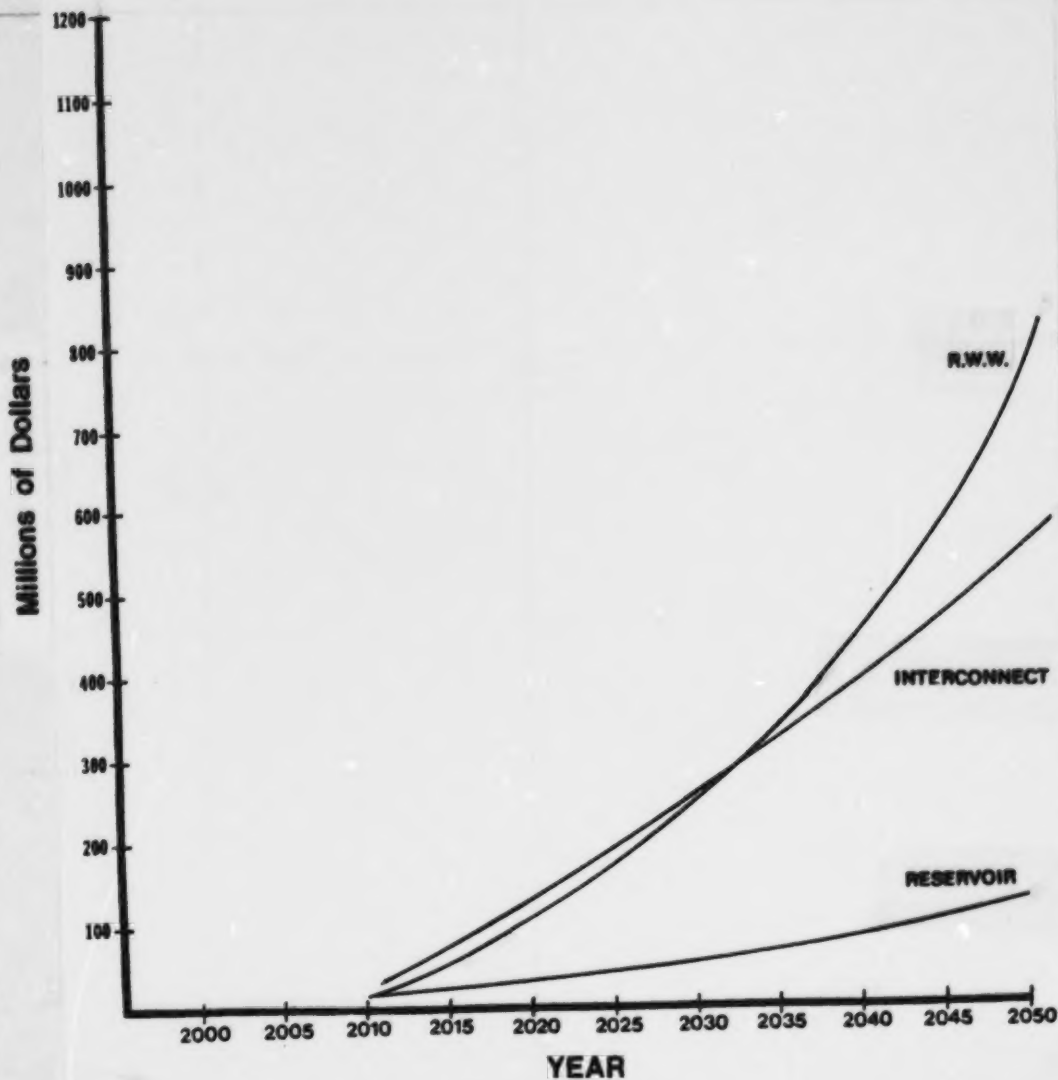
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Figure 43. Cumulative time-investment curve (based on 1932 river flow conditions).

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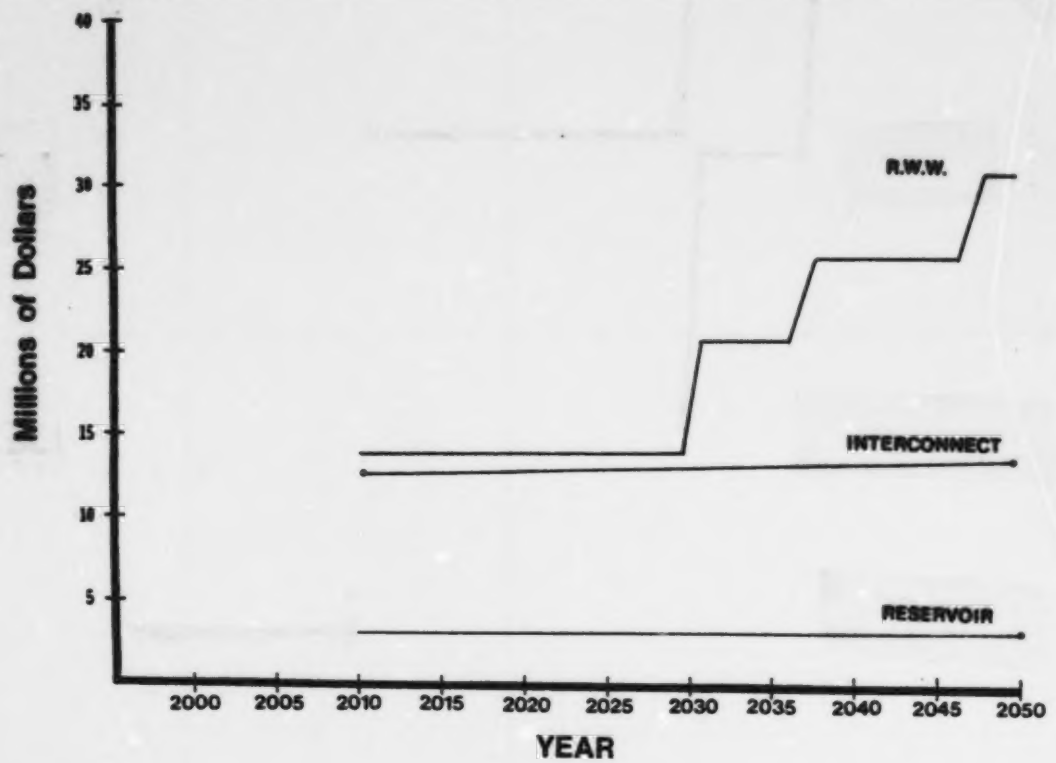
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Figure 44. Time-investment curve (annual cost) (based on 1932 river flow).

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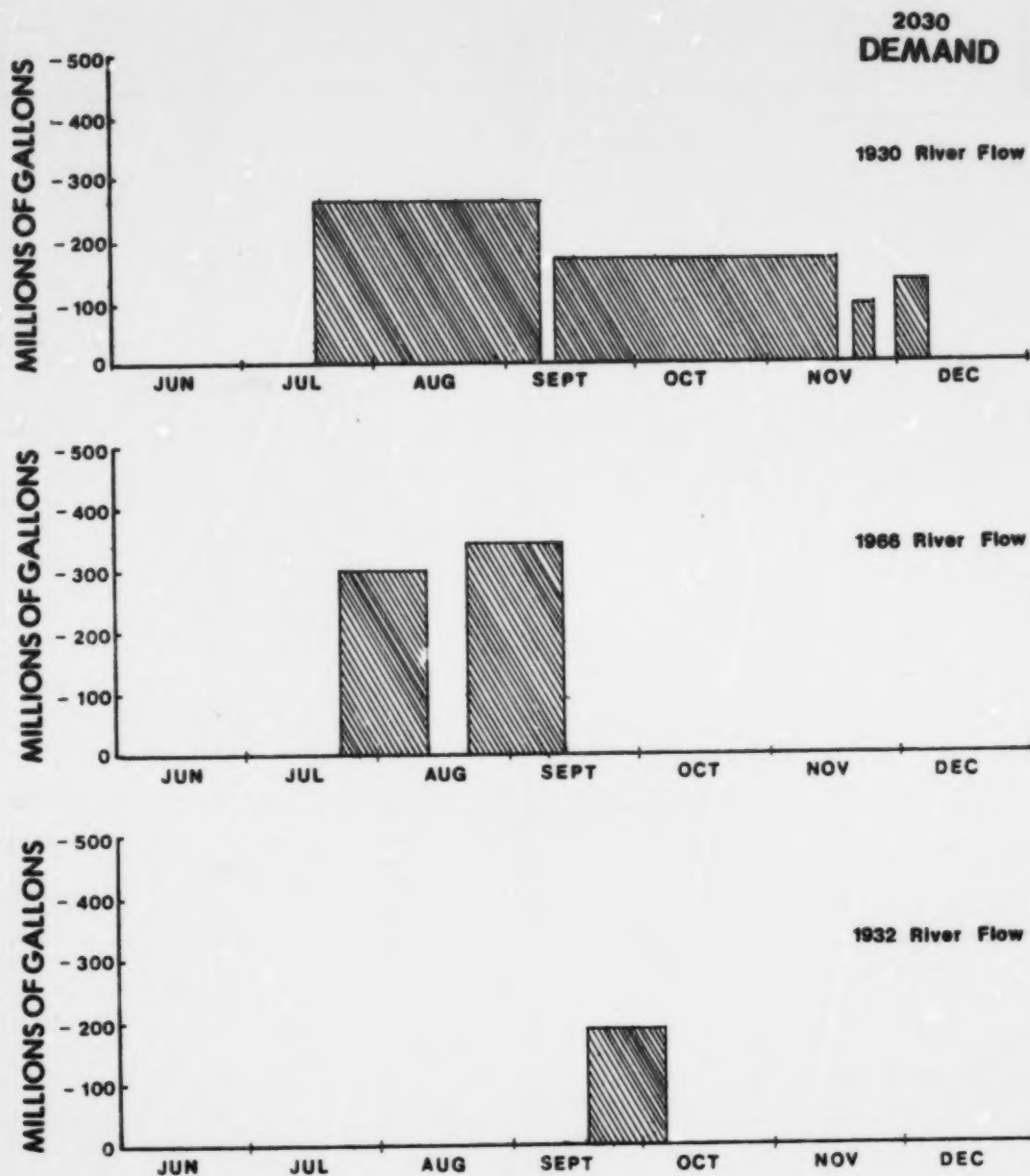


Figure 45. Deficit assuming optimal release pattern for Bloomington (2030 demand) without conservation.

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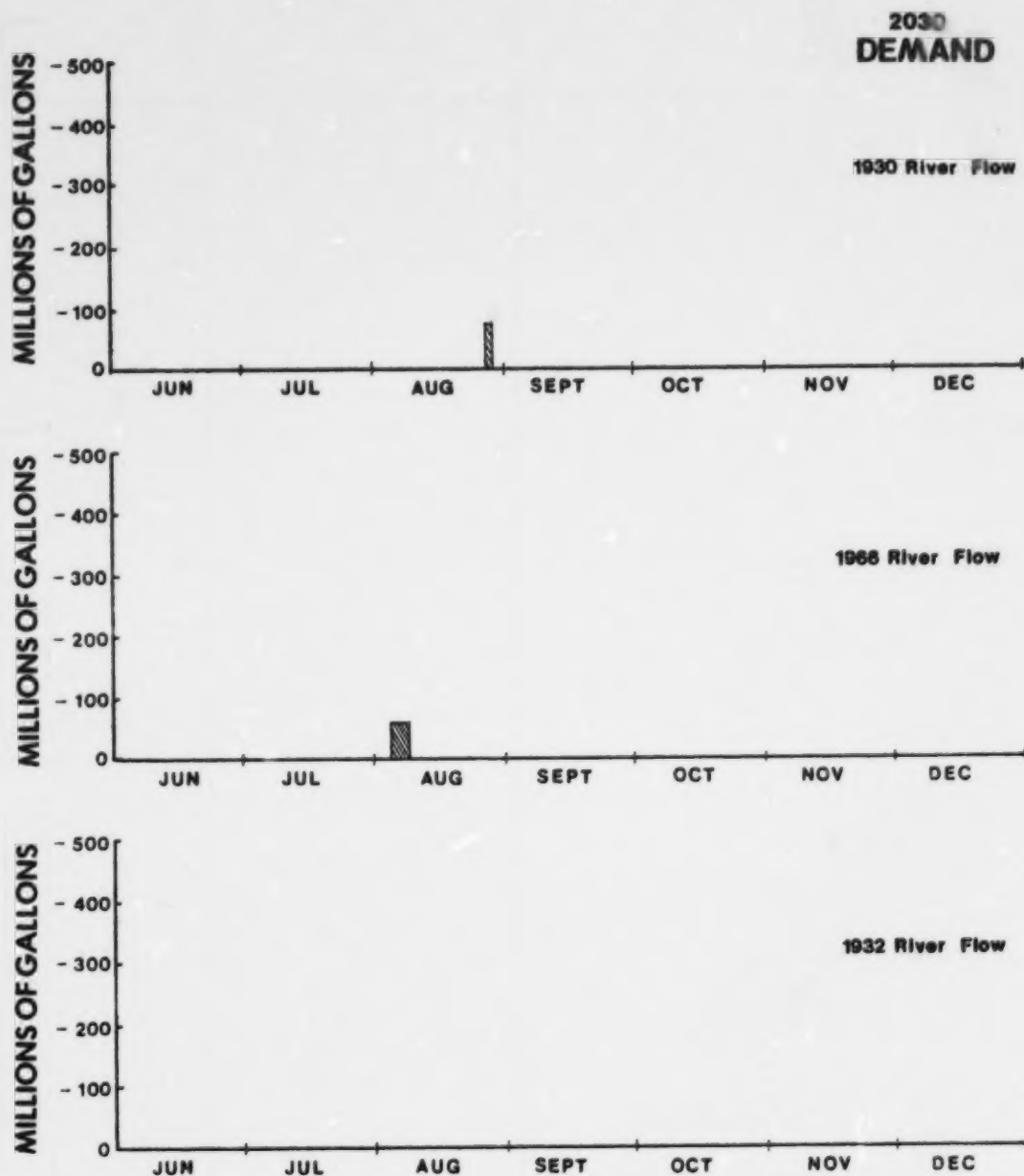


Figure 46. Deficit assuming optimal release pattern for Bloomington (2030 demand) with conservation.

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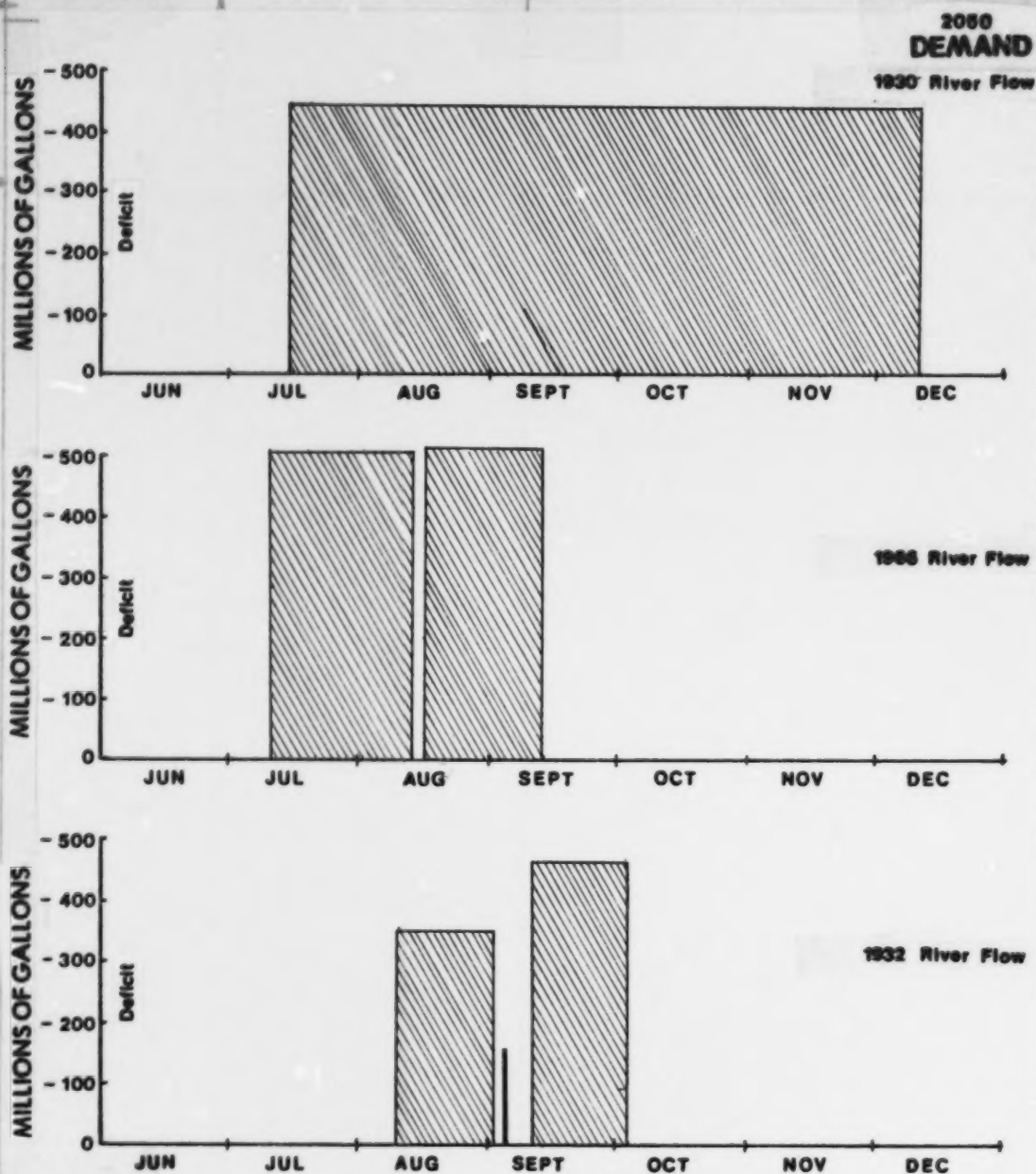
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Figure 47. Deficit assuming optimal release pattern for Bloomington (2050 demand) without conservation.

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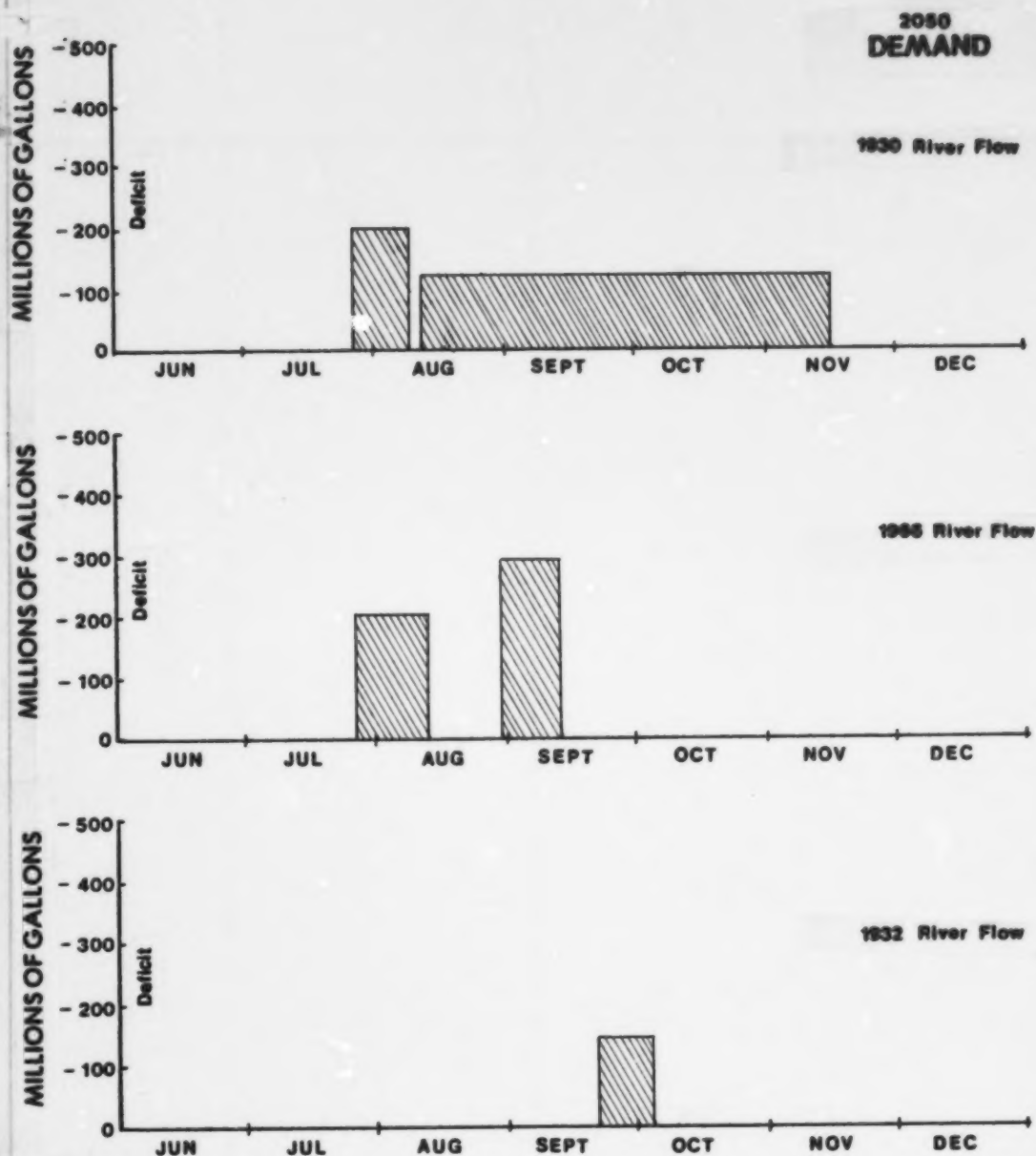
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Figure 48. Deficit assuming optimal release pattern for Bloomington (2050 demand) with conservation.

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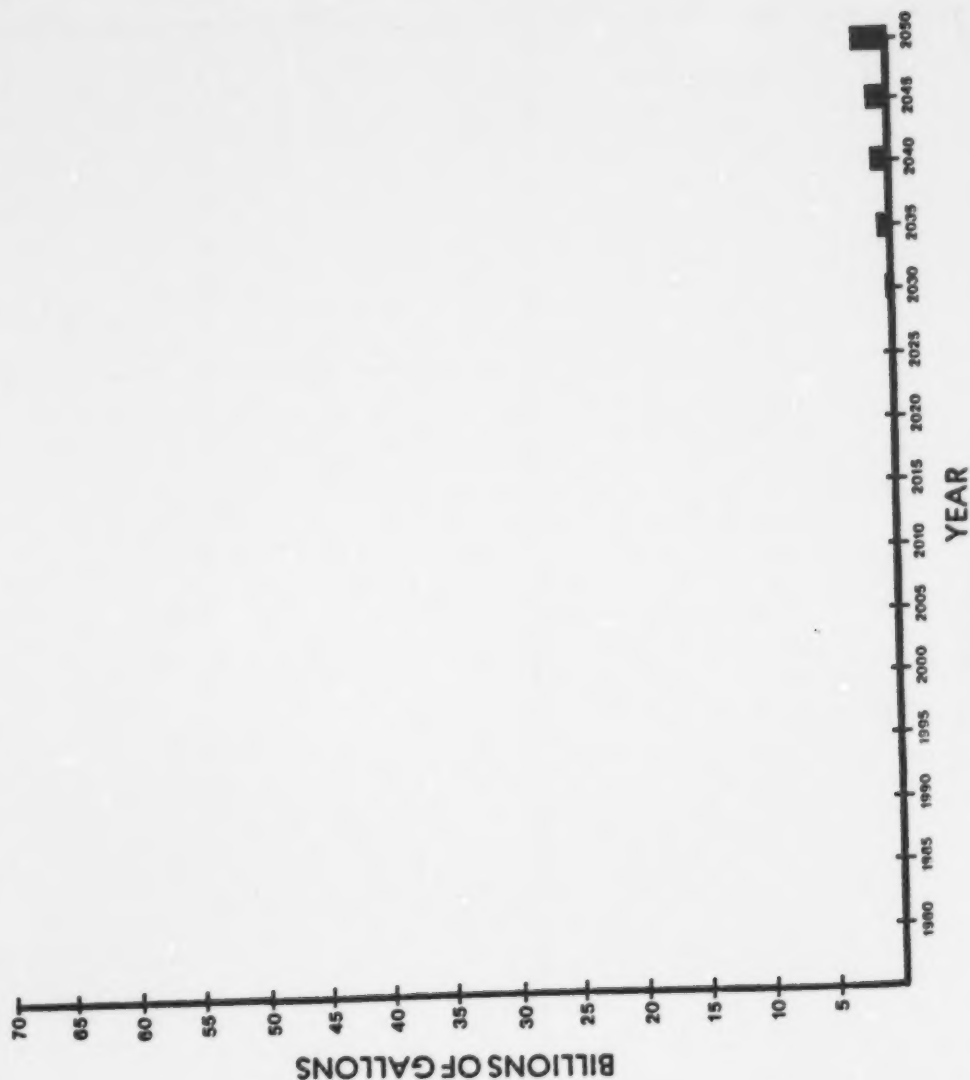


Figure 49. Magnitude of yearly deficits with Bloomington Reservoir on line with conservation (1930 river flow).

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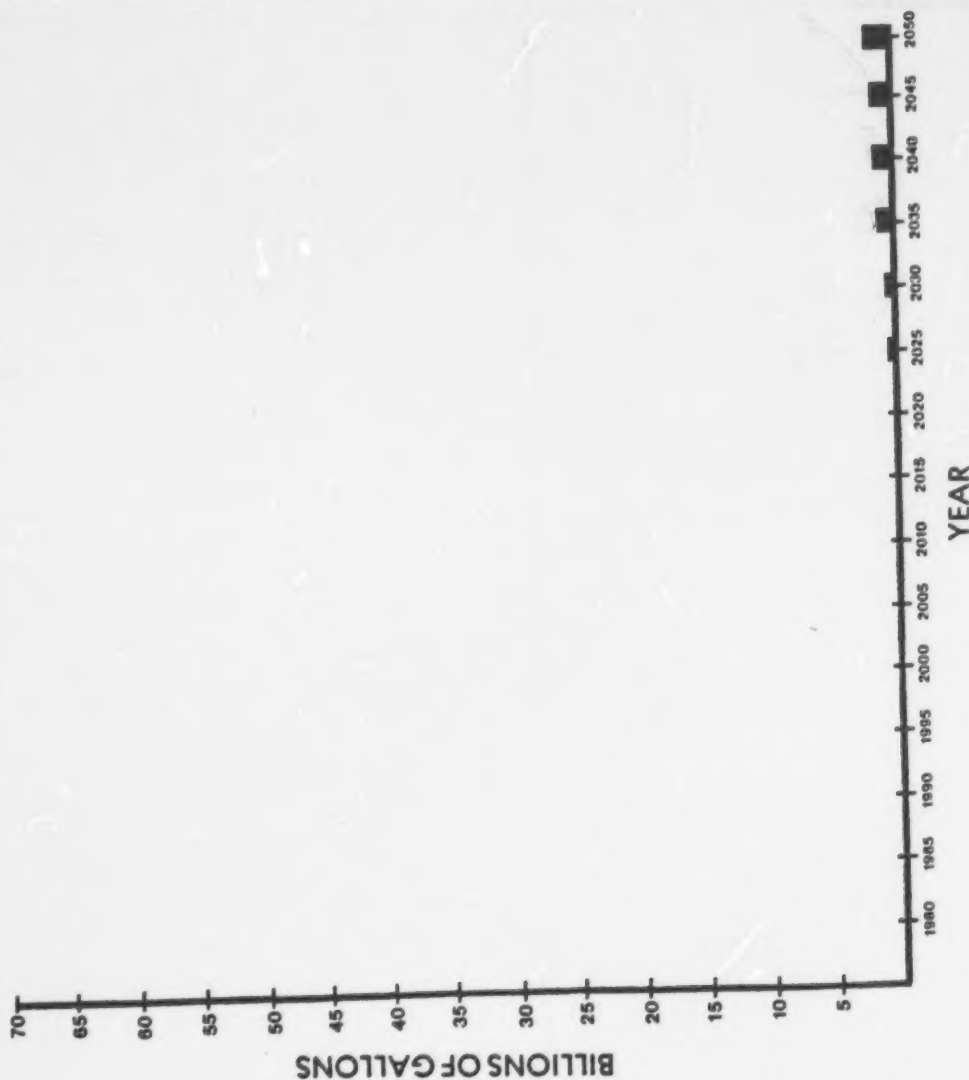


Figure 50. Magnitude of yearly deficits with Bloomington Reservoir on line with conservation (1966 river flow).

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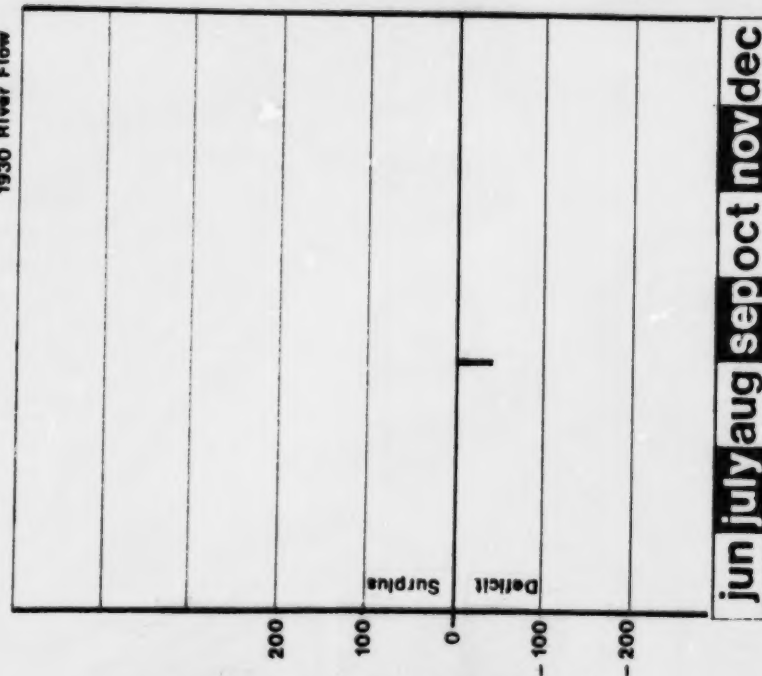
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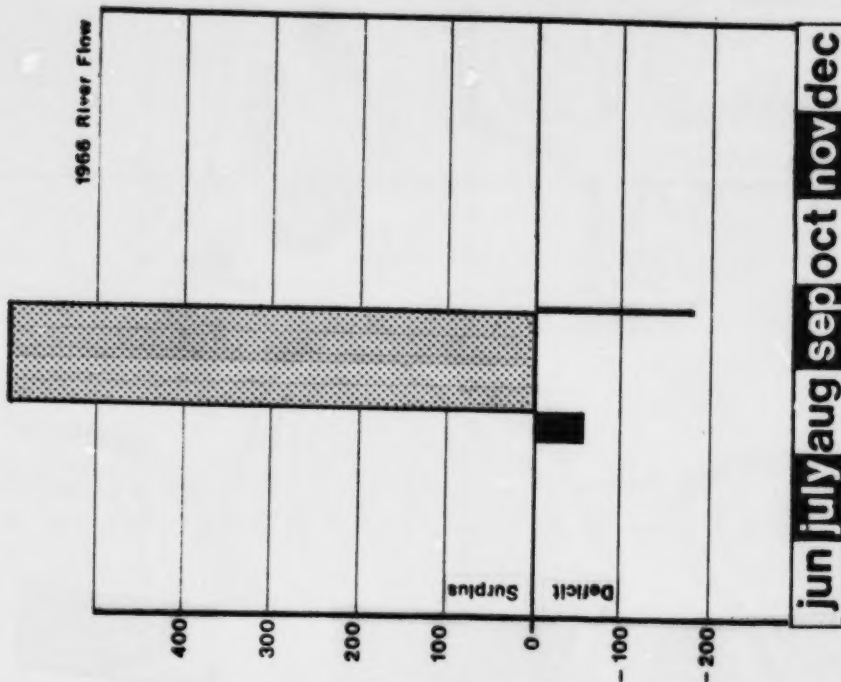
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Figure 51. Deficits with conservation (2030 demand).

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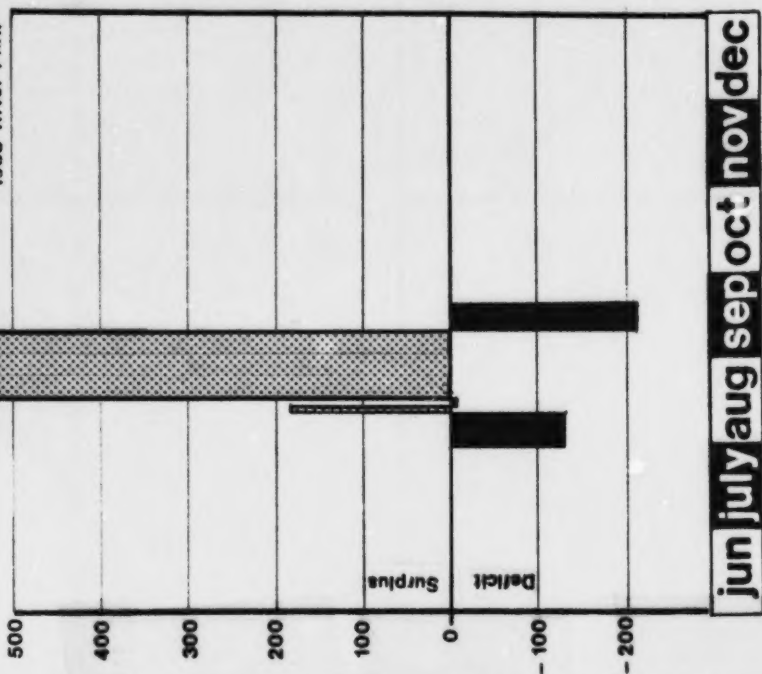
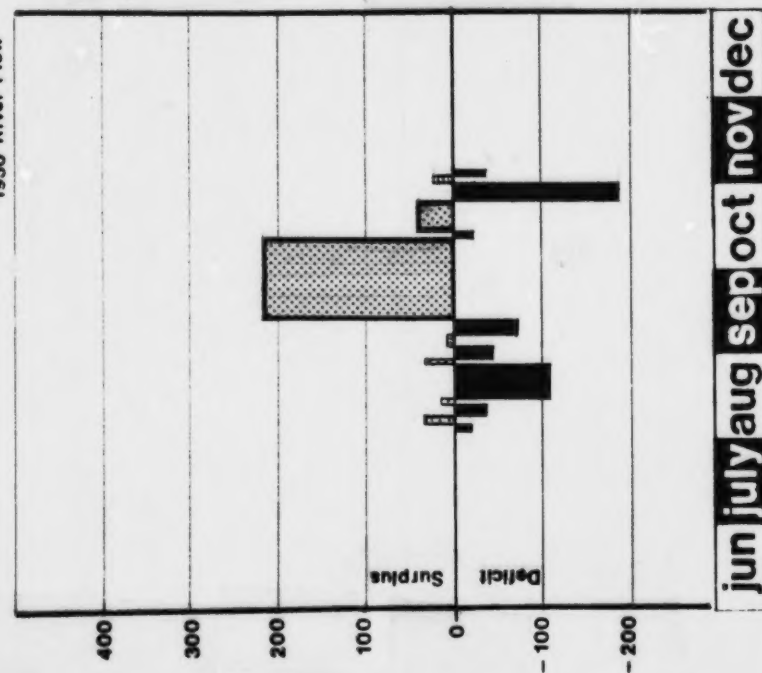
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Figure 52. Deficits with conservation (2050 demand).

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business and that appropriate costs be assessed against them.

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Table 22 shows the estimated purchase and installation cost, per family, used in this report for retrofitting low-flow devices. It is assumed that installation of flow devices in new homes has a zero cost. The cost of retrofitting low-flow devices in places of business is assumed to be 1/10 of the household figure. An annualized per capita cost is calculated from this table. Table 23 shows the percent of new and existing homes that would be required to install water conserving devices to meet a 2.5 percent reduction in total use after a period of 5 years, for D.C., WSSC, and Virginia. It is entirely possible that 100 percent of new homes would install these devices, therefore exceeding the required reduction in demand. For purposes of this analysis the old housing stock is assumed stable. The costs of conservation, therefore, are associated with the number of existing (1981) houses that is retrofitted to meet the conservation target. The employment percentages are shown in Table 24. The total cost for conservation is shown in Table 25. The cumulative cost is shown in Figure 53.

To understand the impact of the costs associated with the various alternatives under consideration, the costs must be contrasted with existing water supply costs. In the following section, the existing costs for the individual water supplies are discussed.

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TABLE 22. COSTS PER FAMILY FOR RETROFITTED LOW-FLOW DEVICES

Device	Unit incremental	
	purchase and installation cost (\$)	Percent Reduction
Flow control showers	25.00	12
Reduced flush toilets	150.00	17
Aeration devices	10.00	1
Annualized cost per family for 15 years at 7% = 20.35		
Annualized cost per capita* = 5.09		

* Assume 1/10 per employment cost for industrial
and manufacturing activities.

Note: from: "Flow Reduction of Wastewater from Households", by
J. Bailey and H. Waldman, Water and Sewage Works. March
1971. pp. 68-70.

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TABLE 23. PERCENT USING WATER CONSERVING DEVICES (RESIDENTIAL)

Year	D. C.				W S S C				V I R G I N I A			
	Percent of new homes		Percent of pre-1975 homes		Percent of new homes		Percent of pre-1975 homes		Percent of new homes		Percent of pre-1975 homes	
	conserving		conserving		conserving		conserving		conserving		conserving	
1980	0.0		0.0		100.0		2.4		70.1		0.0	
1985	100.0		14.2		95.3		0.0		69.9		0.0	
1990	100.0		19.3		92.8		0.0		75.8		0.0	
1995	100.0		24.5		98.1		0.0		84.1		0.0	
2000	100.0		31.5		100.0		3.5		93.5		0.0	
2005	100.0		38.2		100.0		8.2		100.0		2.7	
2010	100.0		46.0		100.0		14.5		100.0		9.5	
2015	100.0		51.7		100.0		21.8		100.0		16.3	
2020	100.0		58.3		100.0		29.7		100.0		25.1	
2025	100.0		64.9		100.0		38.7		100.0		32.8	
2030	100.0		71.4		100.0		48.5		100.0		42.6	
2035	100.0		77.5		100.0		57.7		100.0		53.6	
2040	100.0		83.6		100.0		68.0		100.0		64.5	
2045	100.0		89.6		100.0		78.8		100.0		76.5	
2050	100.0		95.3		100.0		90.2		100.0		89.1	

TABLE 24. PERCENT USING WATER CONSERVING DEVICES (OTHER USERS)

Year	D. C.			W S S C			V I R G I N I A		
	Percent of new business		Percent of pre-1975 business conserving	Percent of new business conserving		Percent of pre-1975 business conserving	Percent of new business conserving		Percent of pre-1975 business conserving
	conserving	new business		conserving	new business		conserving	new business	
1980	100.0		0.8		58.0	0.0	59.3		0.0
1985	100.0		3.3		60.0	0.0	67.3		0.0
1990	100.0		8.9		63.8	0.0	69.9		0.0
1995	100.0		13.0		67.9	0.0	72.3		0.0
2000	100.0		17.6		74.9	0.0	80.0		0.0
2005	100.0		23.1		80.9	0.0	86.3		0.0
2010	100.0		29.1		86.8	0.0	92.1		0.0
2015	100.0		35.5		92.7	0.0	97.8		0.0
2020	100.0		42.3		100.0	1.3	100.0		5.0
2025	100.0		49.7		100.0	7.4	100.0		14.5
2030	100.0		57.4		100.0	19.2	100.0		26.0
2035	100.0		66.6		100.0	32.8	100.0		38.8
2040	100.0		74.1		100.0	48.0	100.0		52.5
2045	100.0		83.0		100.0	64.9	100.0		68.2
2050	100.0		92.1		100.0	83.4	100.0		85.3

TABLE 25. TOAL COST OF WATER CONSERVATION (\$)

Year	Residential	Other	Total
1980	153,432.96	2,650.37	156,083.33
1985	537,748.32	10,932.99	548,681.31
1990	730,883.28	29,485.34	760,368.62
1995	927,805.20	43,068.48	970,873.68
2000	1,416,648.80	58,307.87	1,474,956.67
2005	2,101,442.13	76,529.38	2,177,971.51
2010	3,128,497.24	96,407.14	3,224,904.38
2015	4,139,956.59	117,610.08	4,257,566.67
2020	5,320,592.27	153,670.41	5,474,262.68
2025	6,518,032.62	212,269.53	6,730,615.15
2030	7,865,032.37	289,222.31	8,154,254.68
2035	9,216,254.31	378,034.77	9,594,289.08
2040	10,632,964.19	466,801.47	11,099,765.66
2045	12,131,058.08	568,340.69	12,699,398.77
2050	13,685,167.42	677,182.15	14,362,349.57

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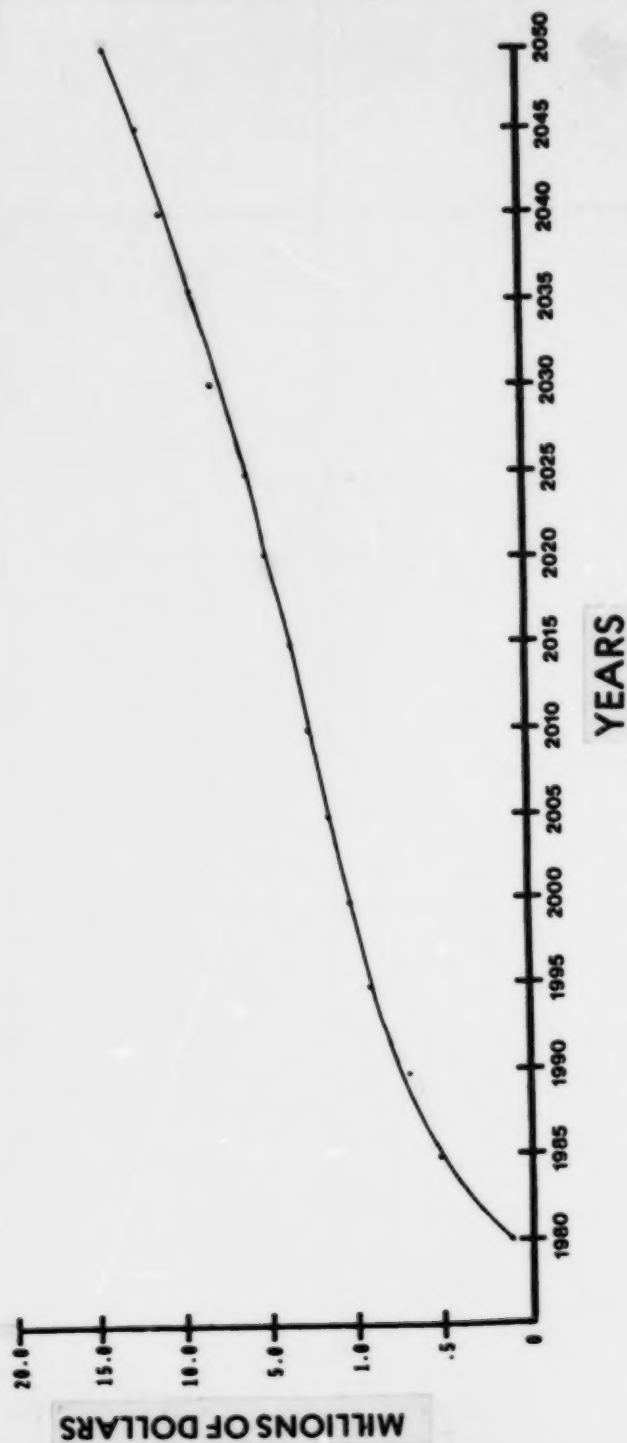


Figure 53. Cost of conservation (Washington, D.C., WMA).

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WATER SUPPLY UTILITY COSTS

A major portion of this study concerned examination of the costs of water supply and water utility management in Washington, D.C. area. The resulting data will provide a sound basis for understanding the impact of the various augmentation alternatives on the cost of existing water supply in the WMA. A detailed cost analysis of all utilities in the WMA that currently withdraw or plan to withdraw water from the Potomac River was completed. These utilities include the Washington Suburban Sanitary Commission, the Corps of Engineers Washington Aqueduct Division, the Fairfax County Water Authority, and the Cities of Rockville, Maryland, and Leesburg, Virginia. In addition, selected wholesale customer utilities of these water purveyors were also studied. Among these water retailers were the water systems of Falls Church, Virginia, Arlington County, Virginia, and the Washington, D.C., Department of Environmental Services, which, for purposes of this analysis, is considered together with the Washington Aqueduct Division as the Washington, D.C., Public Water Supply. Figure 54 is a map of the service areas of the water supply utilities in the WMA that are included in this analysis.

The analysis includes a detailed description of each of the water utilities mentioned and presented in Appendix E. Detailed water supply costs for each utility are shown in the computer printouts in Appendix E. The printouts provide a comprehensive cost analysis for each utility over a 10-year period. Narratives were developed for each utility in an attempt to explain the operating conditions that affect each utility. Data summaries of each of the utilities studied are presented in the following sections.

WASHINGTON SUBURBAN SANITARY COMMISSION (WSSC)

The WSSC is a public agency, established by the Maryland General Assembly in 1918, to serve suburban Montgomery and Prince Georges Counties. One of its chief functions is operation of the water supply system. At the time of WSSC's creation, the Sanitary District served by the Commission consisted of 95 square miles with a population of approximately 32,000 and a water consumption of about 250,000 gallons per day. By 1975, the service area had grown to include about 1,000 square miles, with a population close to 2 million and an average water consumption of 124 MGD.

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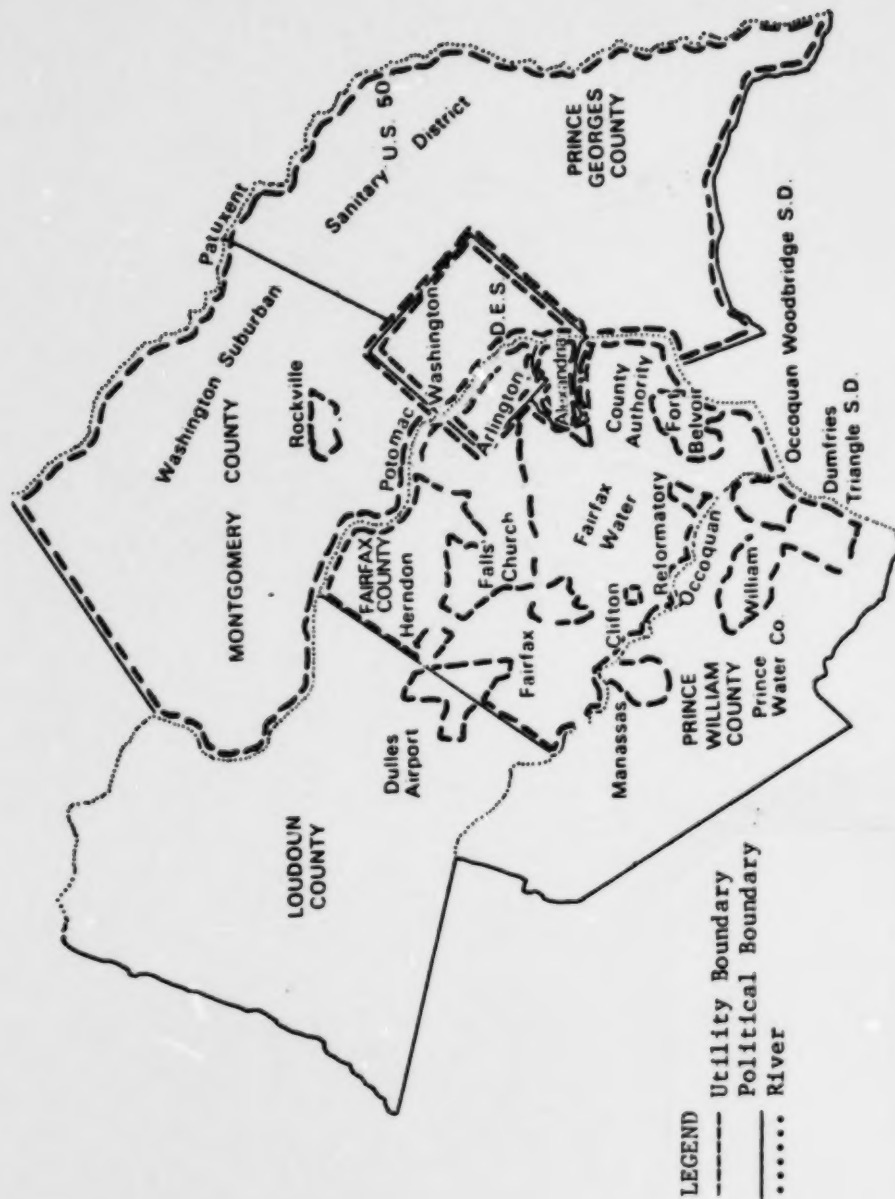


Figure 54. Washington Metropolitan Area water utilities service area map.

The WSSC is led by a six-member commission, composed of three members each from Prince Georges and Montgomery Counties, Maryland. Near the end of fiscal year 1976, the agency was reorganized to consolidate most functions under three organizational units: the Bureau of Maintenance and Operations, the Bureau of Engineering, and the Bureau of Administration.

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The principal sources of water supply for the WSSC are the Patuxent and Potomac Rivers. The Patuxent River, winding along the northern borders of Montgomery and Prince Georges Counties, supports two single-purpose water supply dams. WSSC owns 6,000 acres of perimeter land around the two lakes maintained under strict soil-water conservation control. The Potomac River, located along the western border of Montgomery County, supplies over 27 billion gallons of water annually to the bicounty area. The Potomac is the larger of the two sources of raw water for the WSSC service area.

Two water filtration plants convert raw or unfiltered water into finished or drinking water. Each of the plants produces drinking water, using slightly different treatment techniques. Schematic diagrams of water treatment facilities are provided in Appendix E. Both the Patuxent and Potomac plants feed finished water to the 3,200-mile interconnected pipeline distribution system. This regional bicounty system does not differentiate between counties or specific localities; thus, many areas in the system receive a mixture of water from both plants.

Cost Analysis

Figure 55 shows the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility, and RPW or the amount of water sold by the utility. Table 26 summarizes the O&M and capital costs over the 10-year period of analysis. These data are divided into the following categories: support services, which include all costs that cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection; acquisition costs, which include all costs associated with acquiring water and transmitting it to the treatment facility; treatment costs, which include all costs associated with purification; and delivery costs, which are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Systems Evaluation

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

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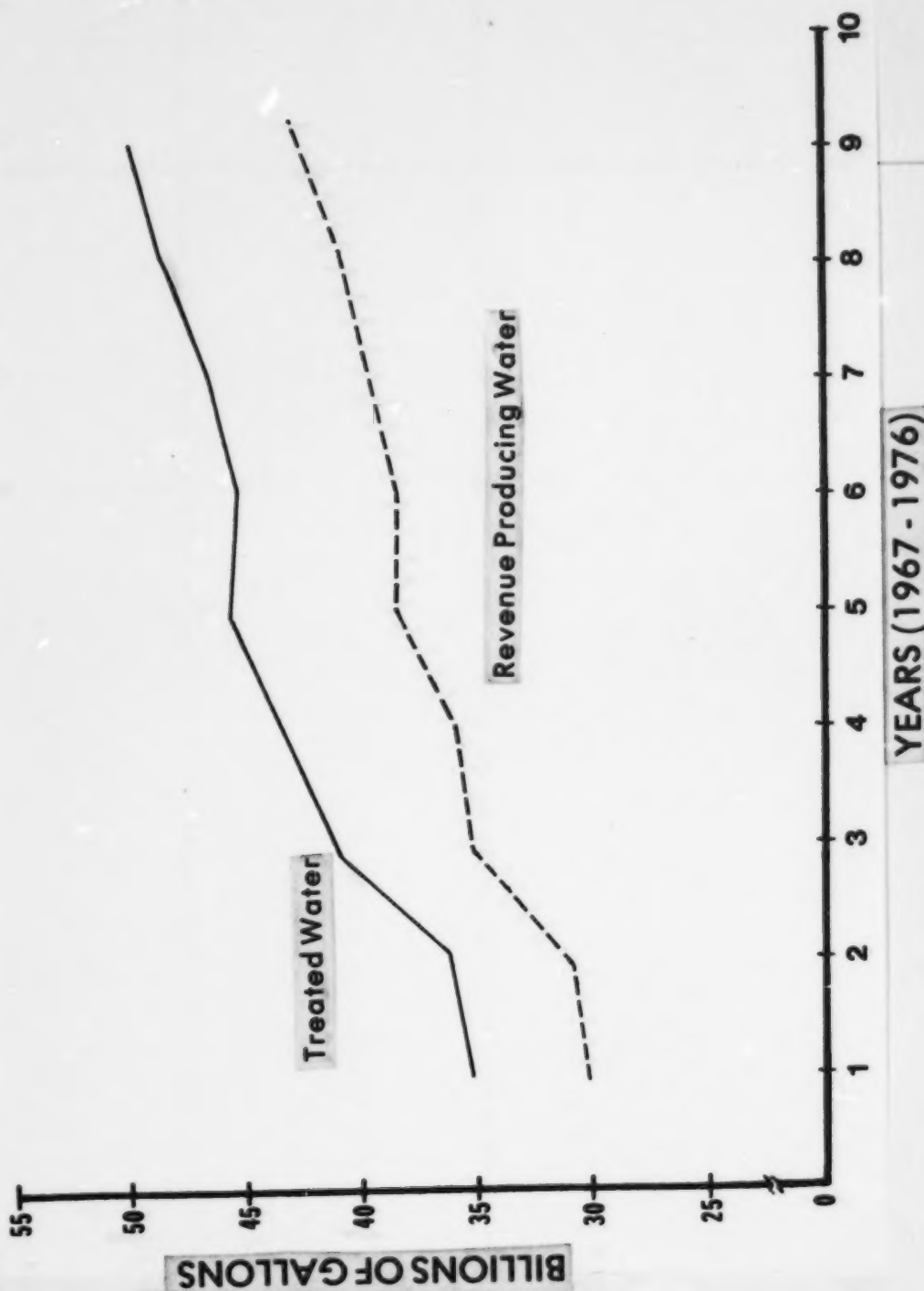


Figure 55. WSSC Water Utility water flow: treated water vs RPW.

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TABLE 26. SUMMARY OF OPERATING AND CAPITAL EXPENDITURES FOR WSSC (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	.501	.577	.698	.718	.819	.837	.900	1.165	1.426	1.561
% of total	11.84	12.06	12.87	11.27	10.59	9.85	8.95	9.71	8.91	9.74
\$/mil gal	17.	19.	20.	20.	22.	22.	23.	29.	30.	37.
Acquisition										
million \$	.213	.225	.246	.276	.332	.307	.449	.459	.543	.587
% of total	5.03	4.69	4.54	4.33	4.29	3.62	4.46	3.82	3.39	3.66
\$/mil gal	7.	7.	7.	8.	9.	8.	12.	11.	13.	14.
Treatment										
million \$	1.067	1.191	1.521	1.720	1.998	2.165	2.496	3.139	4.174	4.548
% of total	25.23	28.90	28.04	26.98	25.85	25.49	28.82	26.16	26.09	28.37
\$/mil gal	36.	38.	43.	48.	53.	57.	64.	78.	99.	108.
Delivery										
million \$	2.450	2.792	2.959	3.661	4.582	5.182	6.210	7.236	9.855	9.336
% of total	57.90	58.35	54.55	57.42	59.27	61.03	61.76	60.31	61.60	58.23
\$/mil gal	82.	90.	85.	102.	121.	136.	159.	181.	235.	222.
Total Operating Costs										
million \$	4.231	4.785	5.424	6.376	7.731	8.490	10.054	11.999	15.997	16.029
\$/mil gal	141.	154.	155.	177.	203.	223.	258.	300.	381.	382.
Depreciation										
million \$	.866	1.041	1.249	1.380	1.585	1.762	1.762	1.793	1.872	2.012
Interest										
million \$	1.724	2.335	2.899	3.478	4.271	4.719	4.623	4.933	5.631	5.726
Total Capital Costs										
million \$	2.589	3.376	4.148	4.559	5.856	6.482	6.386	6.726	7.504	7.738
Total Operating and Capital Costs										
million \$	6.821	8.161	9.572	11.234	13.587	14.972	16.440	18.725	23.501	23.767
\$/mil gal	227.	263.	273.	312.	358.	394.	422.	468.	560.	566.

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ment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure 56 is a map of the utility service area including major water utility facilities. Figure 57 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

PUBLIC WATER SYSTEM FOR D.C.

The Public Water System for D.C. is operated by two entirely separate organizations; the supply portion of the system is operated by the Washington Aqueduct Division (WAD) of the U.S. Army Corps of Engineers, and the delivery portion is operated by elements of the Department of Environmental Services (DES) which is one of 17 operating departments of the D.C. Government. WAD and DES operations and accounting are entirely separate and the data were gathered separately (see Appendix E). The two operations were combined for this report into one system. It is often viewed as such by people in WMA. The supply function was given to the Secretary of War from 1851 to 1867, and thereafter to the U.S. Army Corps of Engineers. The supply portion consists of the facilities required to collect the water from the Potomac River at its Great Falls and Little Falls intakes above Washington, convey it to the City, store and treat the raw water, and pump a portion of it into the delivery system. The delivery portion consists of the facilities required to receive, store, pump, distribute, and meter purified water furnished from the supply portion of the system.

The Potomac River, the third largest river on the Atlantic Seaboard, is the source of water for Washington, D.C. Water supply intakes are located at Great Falls, Maryland, about 10 miles northwest of the D.C. boundary, and at Little Falls, Maryland, approximately 1.5 miles upstream from Chain Bridge. Water is treated in two filter plants: the McMillan plant and the Dalecarlia filtration plant. Water is pumped to four service areas within the District of Columbia, and through these areas to metropolitan Maryland and to Arlington County and Falls Church, Virginia.

Cost Analysis

Figure 58 shows the 10-year demand for water. The two lines on the graph represent both treated and revenue-producing water. O&M costs and capital costs are shown in Table 27. Separate costs for COE and DC-DES are included in Appendix E.

Systems Evaluation

Figure 59 shows the water intakes, treatment and distribution facilities, and general flow pattern for the Washington D.C.-DES system. Figure 60 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

WASHINGTON SUBURBAN SANITARY COMMISSION FACILITIES MAP

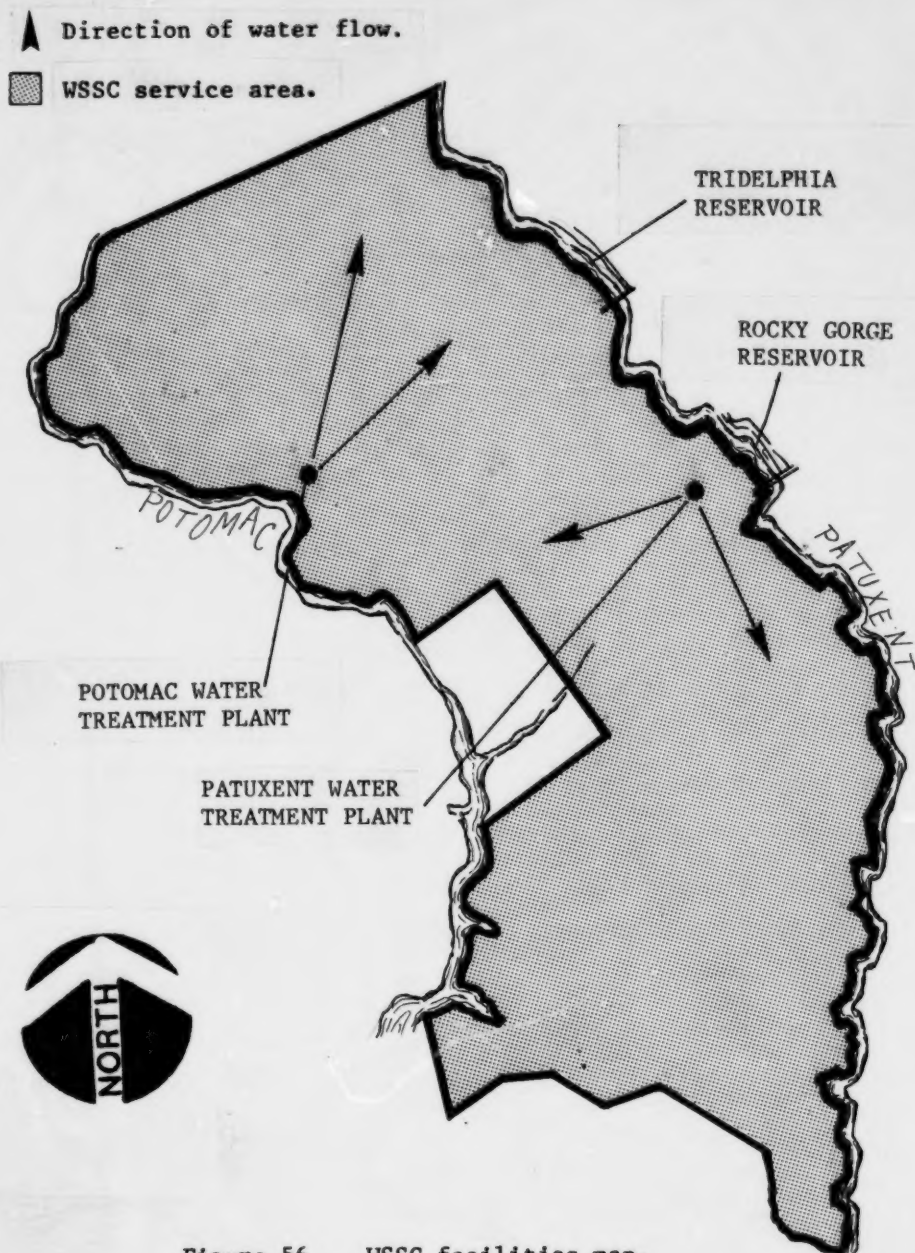


Figure 56. WSSC facilities map.

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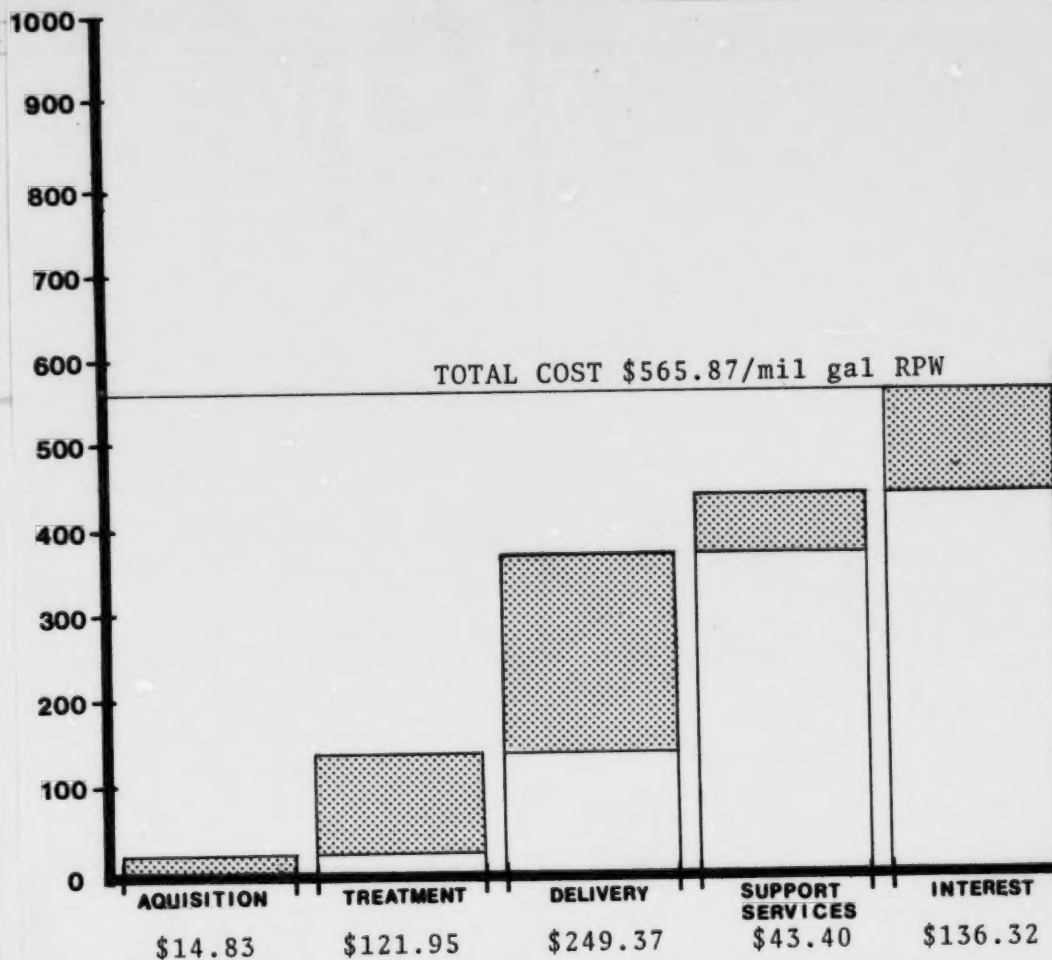


Figure 57. WSSC allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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TABLE 27. SUMMARY OF OPERATING AND CAPITAL EXPENDITURES FOR D.C. WATER SYSTEM (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	2,592	2,750	2,884	3,150	3,509	3,739	4,225	4,077	4,368	4,101
% of total	33.10	33.14	32.20	31.91	32.90	33.59	35.04	32.68	31.37	28.30
\$/mil gal	39.	41.	41.	45.	48.	50.	56.	55.	62.	57.
Acquisition										
million \$	.203	.191	.165	.158	.254	.265	.314	.350	.391	.380
% of total	6.12	5.37	4.38	3.42	5.50	5.40	5.97	6.20	5.60	5.12
\$/mil gal	3.	3.	2.	2	3.	4.	4.	5.	6.	5.
Treatment										
million \$	1,333	1,418	1,502	1,815	1,964	2,119	2,321	2,367	3,065	3,522
% of total	40.23	39.79	39.90	43.84	42.52	43.22	44.19	41.90	43.84	47.46
\$/mil gal	20.	21.	21.	26.	27.	29.	31.	32.	44.	49
Delivery										
million \$	3,702	3,937	4,404	4,749	4,939	5,010	5,012	5,682	6,099	6,490
% of total	47.28	47.46	49.18	48.11	46.30	45.00	42.58	45.54	43.80	44.78
\$/mil gal	56.	58.	62.	67.	68.	67.	68.	76.	87.	90.
Total Operating Costs										
million \$	7,830	8,296	8,955	9,871	10,666	11,134	11,771	12,477	13,924	14,493
\$/mil gal	119.	123.	126.	140.	146.	150.	159.	167.	198.	201.
Depreciation										
million \$	3,367	3,368	3,433	3,498	3,530	3,538	3,581	3,581	3,663	3,779
Interest										
million \$	.770	.820	.787	.800	.774	1.041	1.121	1.210	1.326	1.518
Total Capital Costs										
million \$	4,137	4,188	4,220	4,298	4,305	4,578	4,702	4,791	4,989	5,297
Total Operating and Capital Costs										
million \$	11,967	12,484	13,175	14,169	14,971	15,712	16,473	17,268	18,913	19,790
\$/mil gal	181.	185	186.	201.	205.	211.	222.	232.	269.	274.

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Figure 58. D.C. Public water system: treated water versus RPW.

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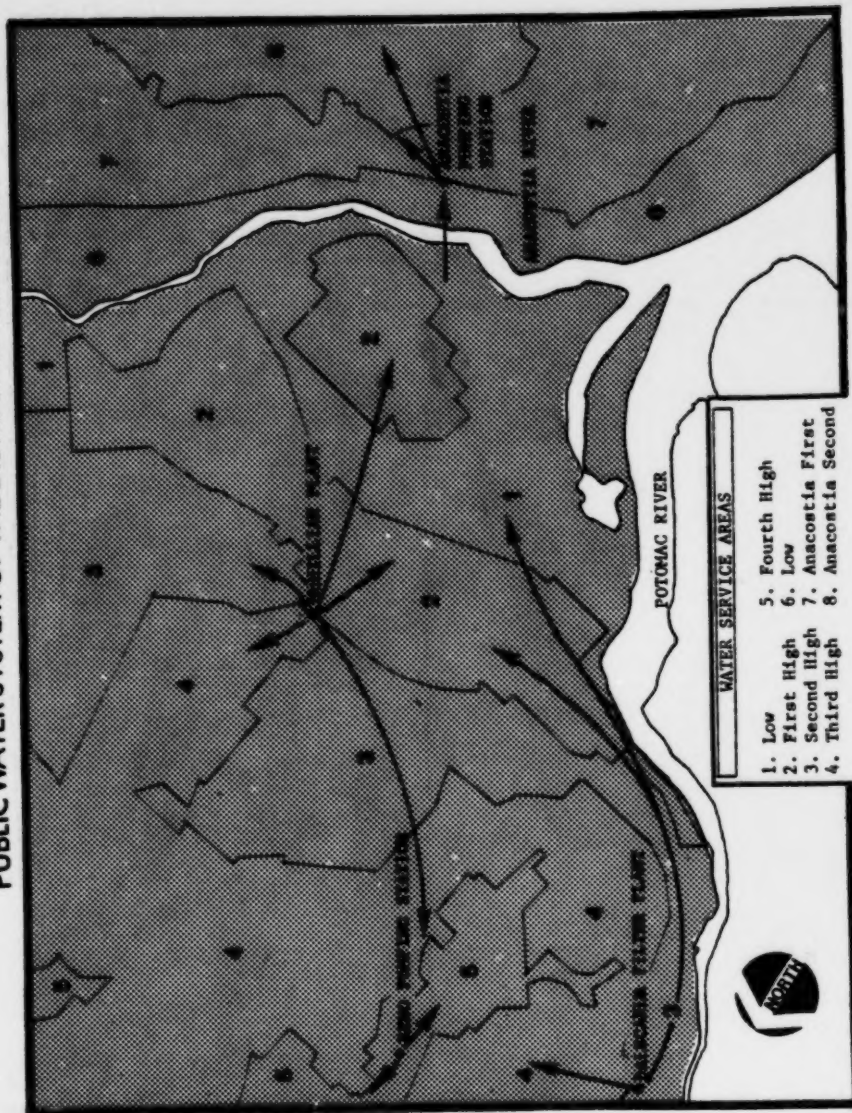
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PUBLIC WATER SYSTEM OF THE DISTRICT OF COLUMBIA



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Figure 59. D.C. Public water system facilities map.

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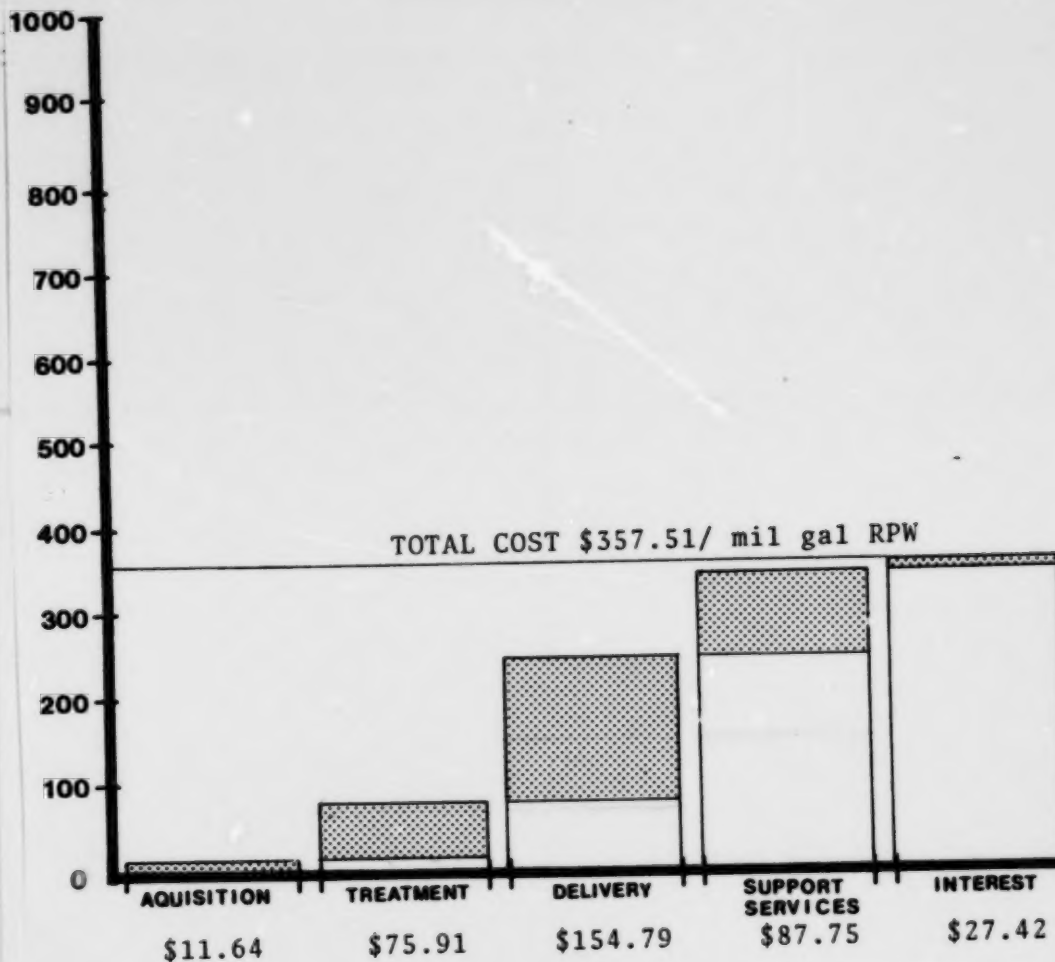


Figure 60.

D.C. Public Water System allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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For example, water for the Public Water System of the District of Columbia is acquired at a cost of \$11.64 mil gal RPW. An additional \$75.91 is spent on the treatment of the water, as is \$154.79 for distribution. Support services and interest costs are also added, yielding a total cost of \$357.51/mil gal of RPW.

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FAIRFAX COUNTY WATER AUTHORITY

The Fairfax County Water Authority, with headquarters in Annandale, Virginia, was created under the Virginia Water and Sewage Authority Act of 1950 by the State Corporation Commission on September 26, 1957, for the purpose of acquiring, constructing, operating, and maintaining an integrated water system to supply and distribute water to Fairfax County. The charter was amended in 1959 to add the provision for sewer systems and sewage disposal systems located within and without Fairfax County. Since 1959, the Authority has acquired 15 water companies consisting of 22 separate water systems. The Alexandria Water Company, acquired in 1967, served 70 percent of the customers gained through the acquisition of the 15 companies. The Authority currently serves approximately two-thirds of the population of Fairfax County, and small areas in adjoining counties. Consisting of four divisions, the Authority is administered by a board of five members appointed by the County Board of Supervisors for staggered terms of three years each.

Approximately 97 percent of FCWA's water comes from the Occoquan River, which flows through Fairfax, Loudoun, and Prince William Counties, with an impounded watershed of approximately 570 square miles. Three percent of the water is groundwater. Water treatment is provided by two interconnecting plants constructed in stages between 1950 and 1973. The combined maximum capacity of these facilities is 99.6 MGD. The transmission and distribution system consists of approximately 1,400 miles of mains, ranging in diameter from 2 to 30 inches. The system is interconnected at 64 locations with 12 other water systems in northern Virginia. Five of the systems have independent water supply sources and seven depend on the Authority for their water supply. In addition to its principal system, the Authority owns and operates seven independent well systems, providing service to about 325 customers in isolated communities.

Cost Analysis

Figure 61 shows the change in water demand over a 6-year period. Both treated water and revenue-producing water are shown on the graph. O&M and capital costs are shown broken down, in the four previously mentioned categories, in Table 28.

System Evaluation

Figure 62 shows the acquisition, treatment, and distribution facilities, and the major water flow pattern for the service area. Figure 63 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made

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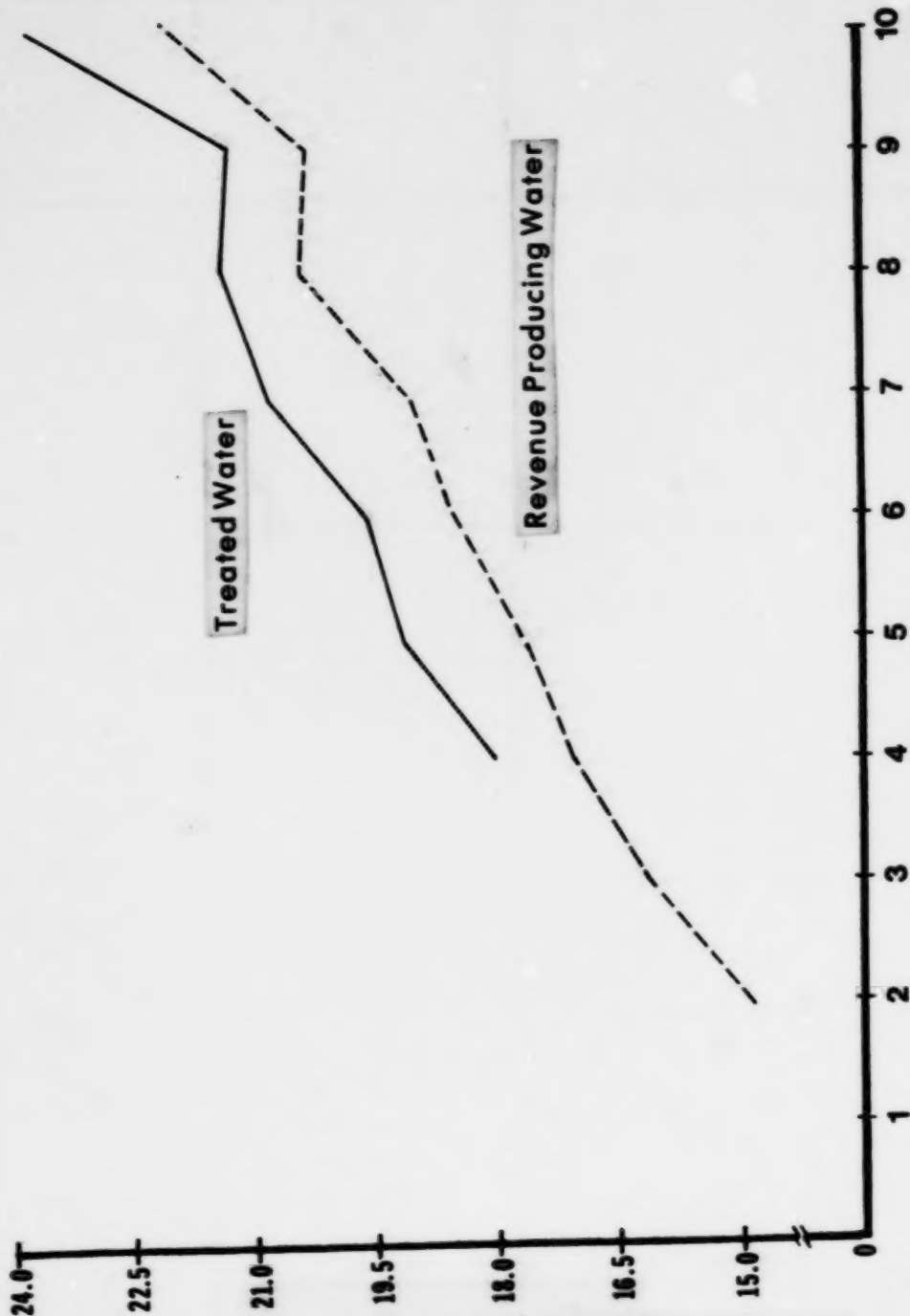
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YEARS (1967-1976)

Figure 61. Fairfax County Water Authority: treated water vs RPW.

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TABLE 28. SUMMARY OF OPERATING AND CAPITAL EXPENDITURES
FOR FAIRFAX COUNTY WATER AUTHORITY (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	--	--	1,000	1,253	1,232	1,406	1,549	1,965	2,108	2,464
Σ of total	--	29,06	38,60	38,81	35,66	35,72	38,94	41,44	38,87	41,47
\$/mil gal	--	65,	62,	76,	70,	76,	81,	96,	104,	111,
Acquisition										
million \$	--	--	250	279	299	341	383	420	400	460
Σ of total	--	8,65	8,65	8,65	8,65	8,65	8,65	8,65	7,75	7,75
\$/mil gal	--	13,	16,	16,	17,	18,	20,	21,	20,	21,
Treatment										
million \$	--	--	564	574	555	586	586	592	693	754
Σ of total	--	19,93	19,51	17,79	16,04	14,88	13,18	12,48	12,78	12,69
\$/mil gal	--	31,	35,	38,	31,	32,	30,	29,	34,	34,
Delivery										
million \$	--	--	1,077	1,122	1,371	1,405	1,916	1,765	2,223	2,263
Σ of total	--	42,37	37,24	36,75	39,45	40,76	43,23	37,21	40,98	38,09
\$/mil gal	--	66,	67,	66,	77,	87,	100,	86,	109,	102,
Total Operating Costs										
million \$	--	2,317	2,891	3,229	3,456	3,938	4,432	4,743	5,424	5,942
\$/mil gal	--	156,	180,	189,	195,	213,	230,	232,	267,	288,
Depreciation										
million \$	--	1,584	1,584	1,584	1,584	1,584	1,587	1,590	1,593	1,596
Interest										
million	--	4,800	3,401	4,935	4,105	4,060	4,011	3,960	3,906	5,105
Total Capital Costs										
million \$	--	8,701	7,876	9,749	9,146	9,581	10,030	10,292	10,923	12,643
Total Operating and Capital Costs										
million \$	--	585,	492,	572,	517,	518,	522,	504,	537,	570,
\$/mil gal	--									

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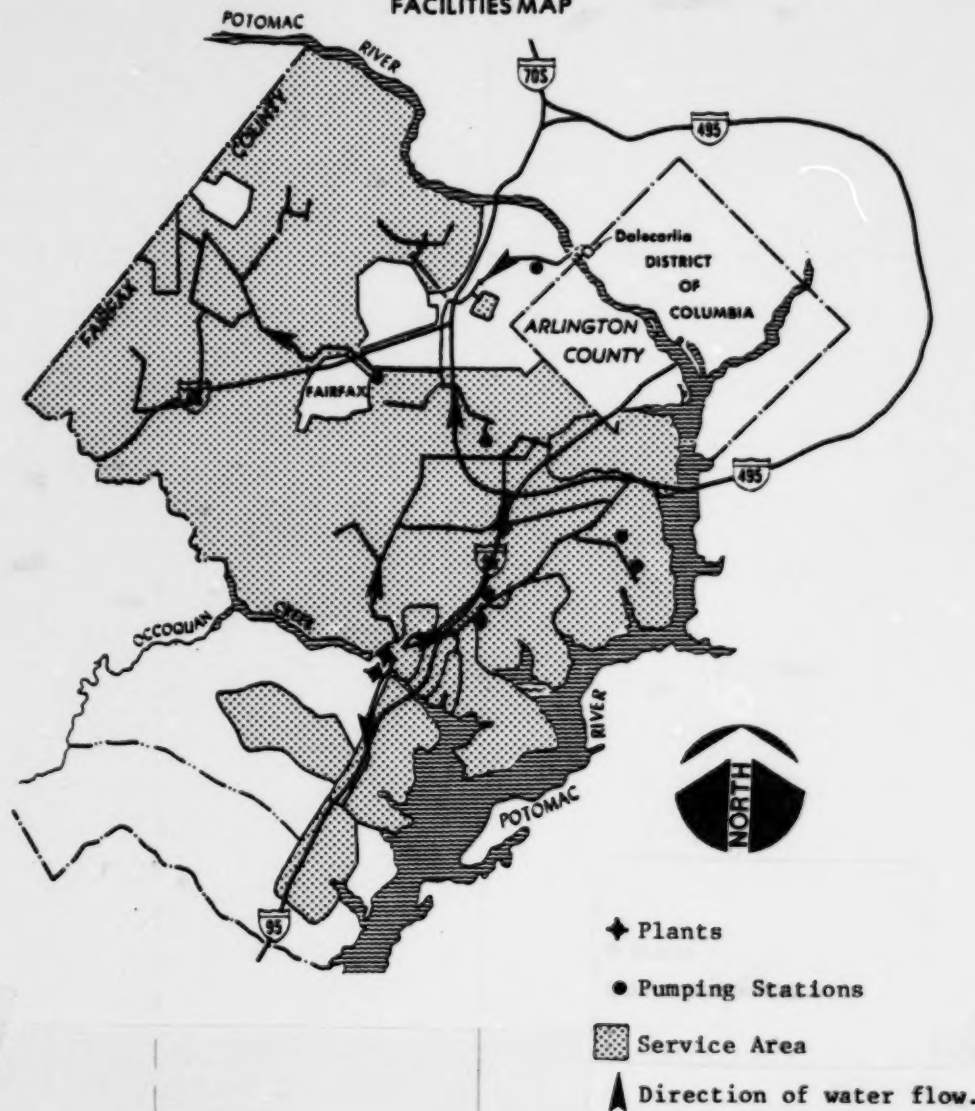
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FAIRFAX COUNTY WATER AUTHORITY
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Figure 62. Fairfax County Water Authority facilities map.

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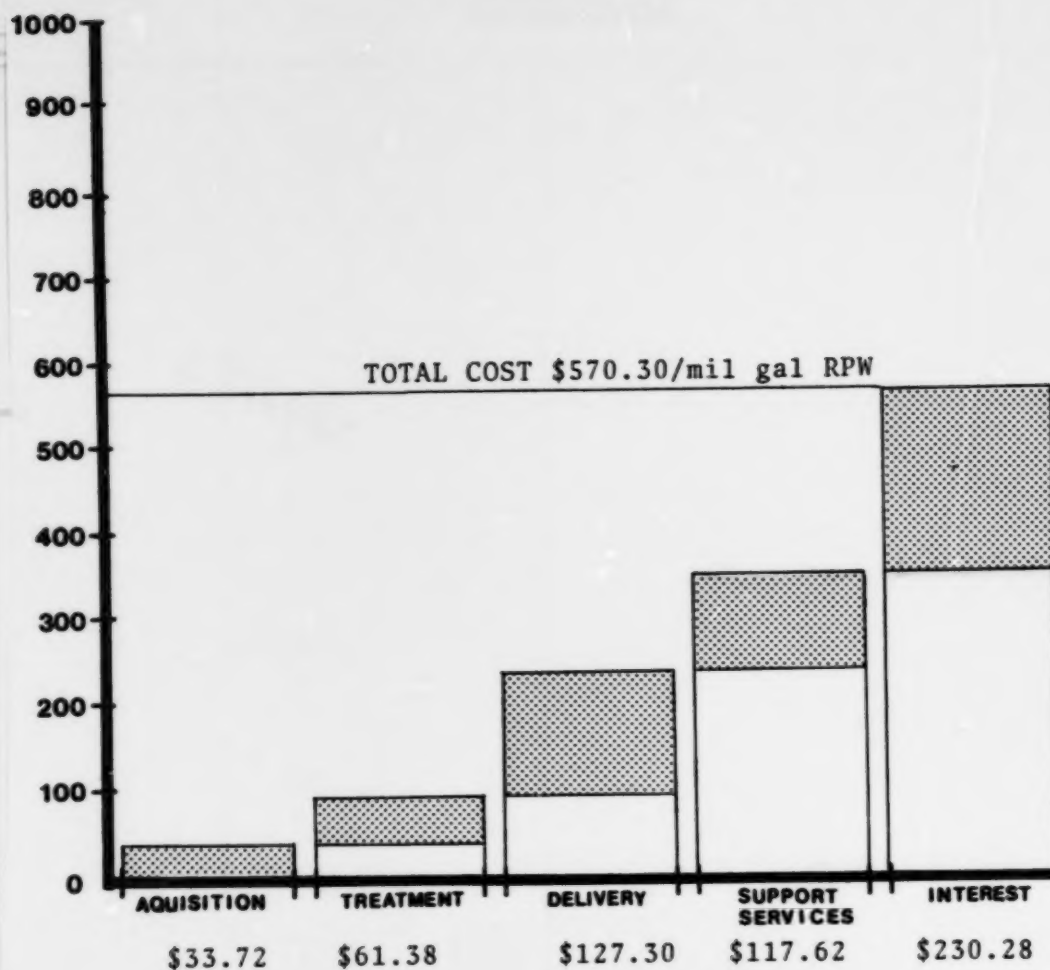


Figure 63. Fairfax County Water Authority allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

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For example, water for the Fairfax County Water Authority is acquired at a cost of \$33.72/mil gal RPW. An additional \$61.38 is spent on the treatment of the water, as is \$127.30 for distribution. Support services and interest costs are also added, yielding a total cost of \$570.30/mil gal of RPW.

ROCKVILLE WATER UTILITY

The Rockville Water Utility is owned and operated by the City of Rockville, Maryland, Department of Public Works. Some billing and administrative responsibilities are assumed by other city departments. The utility serves the City of Rockville and a few customers in surrounding Maryland.

The utility's intake structure is located on the towpath of the Chesapeake and Ohio Canal, about 1.5 miles upstream from the Great Falls Dam and 0.6 mile downstream from Swains Lock. The 12 MGD water treatment plant was placed in operation in 1958 and additional units were added in 1967. Distribution and transmission are provided by five storage facilities.

Cost Analysis

Figure 64 shows the amount of treated and revenue-producing water for the 10-year period of analysis. O&M and capital costs for the 10 years are shown in Table 29.

Systems Evaluation

Figure 65 shows the acquisition, treatment, distribution, and transmission facilities, and the general flow pattern for the utility. Figure 66 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Rockville Water Utility is acquired at a cost of \$52.83/mil gal RPW. An additional \$139.73 is spent on the treatment of the water, as is \$224.89 for distribution. Support services and interest costs are also added, yielding a total cost of \$618.50/mil gal of RPW.

ARLINGTON COUNTY WATER UTILITY

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The Arlington County Water Utility is owned by the county government and operated by the Department of Utilities. It is headed by a director who reports to the county manager. Arlington County purchases 100 percent of its water from the WAD. The water is treated at the Dalecarlia

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MILLIONS OF GALLONS

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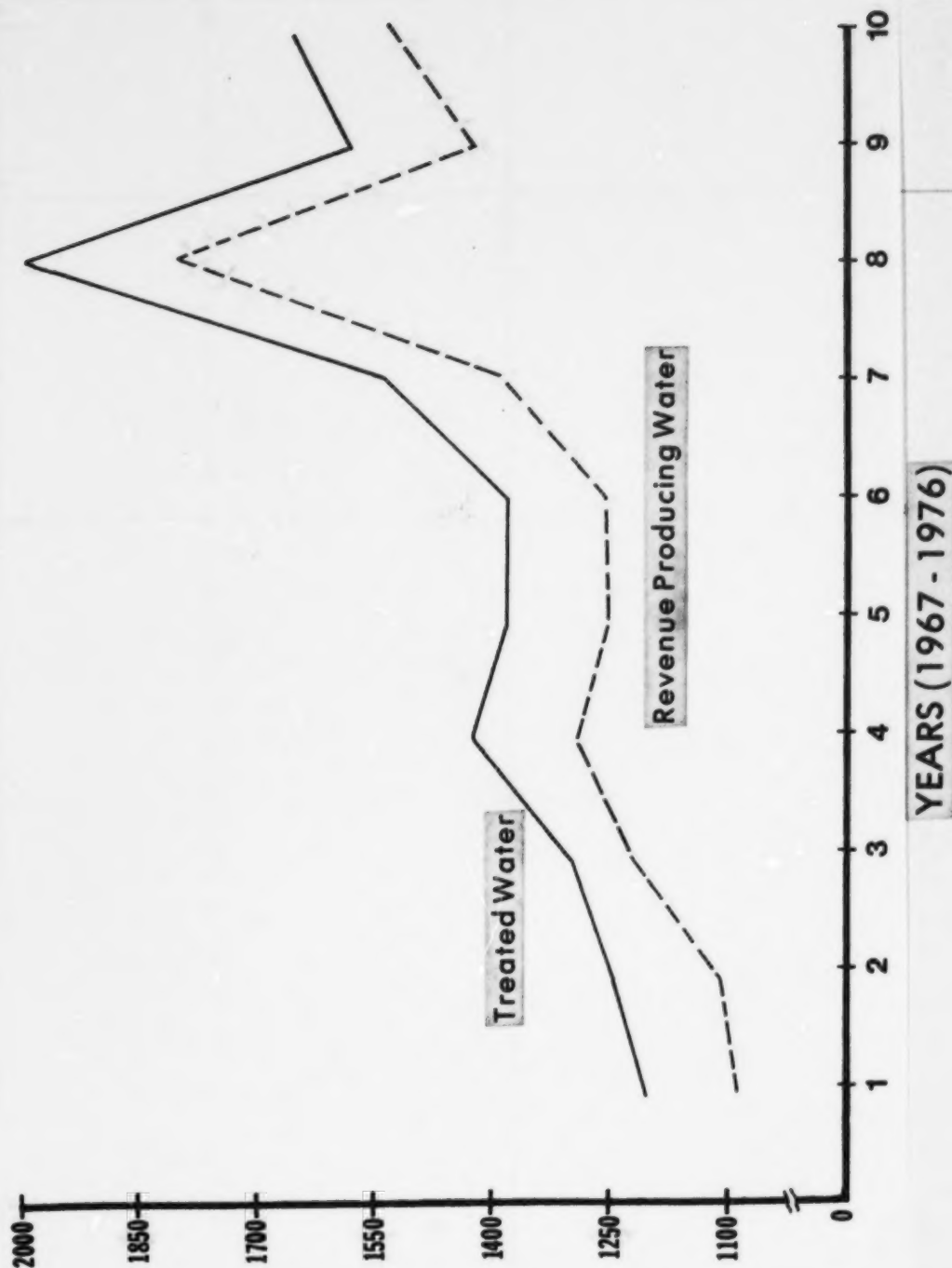


Figure 64. Rockville Water Utility water flow: treated water vs RPW.

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TABLE 29. SUMMARY OF OPERATING AND CAPITAL EXPENDITURES FOR ROCKVILLE (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	.060	.064	.071	.080	.092	.111	.113	.132	.152	.197
% of total	25.10	25.00	22.56	21.17	22.81	25.24	23.12	24.36	20.35	26.05
\$/mil gal	55.	57.	59.	61.	74.	89.	82.	74.	106.	131.
Acquisition										
million \$	.018	.019	.022	.040	.036	.035	.040	.050	.069	.076
% of total	7.38	7.57	7.12	10.07	8.85	7.88	8.23	9.25	9.25	10.04
\$/mil gal	16.	17.	19.	31.	29.	28.	29.	28.	48.	51.
Treatment										
million \$	.085	.081	.118	.113	.128	.140	.140	.140	.175	.203
% of total	35.38	31.56	37.61	29.99	31.70	31.77	28.65	25.72	23.43	26.85
\$/mil gal	78.	72.	98.	87.	103.	112.	102.	78.	122.	135.
Delivery										
million \$	.077	.092	.103	.144	.148	.154	.195	.221	.351	.280
% of total	32.14	35.87	32.71	38.16	36.64	35.10	40.00	40.69	46.97	37.06
\$/mil gal	71.	82.	85.	111.	119.	124.	142.	124.	265.	187.
Total Operating Costs										
million \$	.260	.256	.314	.377	.404	.440	.487	.543	.748	.756
\$/mil gal	221.	230.	261.	290.	325.	354.	355.	305.	522.	504.
Depreciation										
million \$	.042	.045	.049	.051	.063	.060	.062	.064	.066	.068
Interest										
million \$	.128	.126	.124	.122	.121	.117	.116	.115	.108	.105
Total Capital Costs										
million \$										
Total Operating and Capital Costs										
million \$	.409	.427	.487	.550	.587	.617	.665	.722	.921	.928
\$/mil gal	378.	383.	405.	423.	472.	496.	485.	405.	643.	619.

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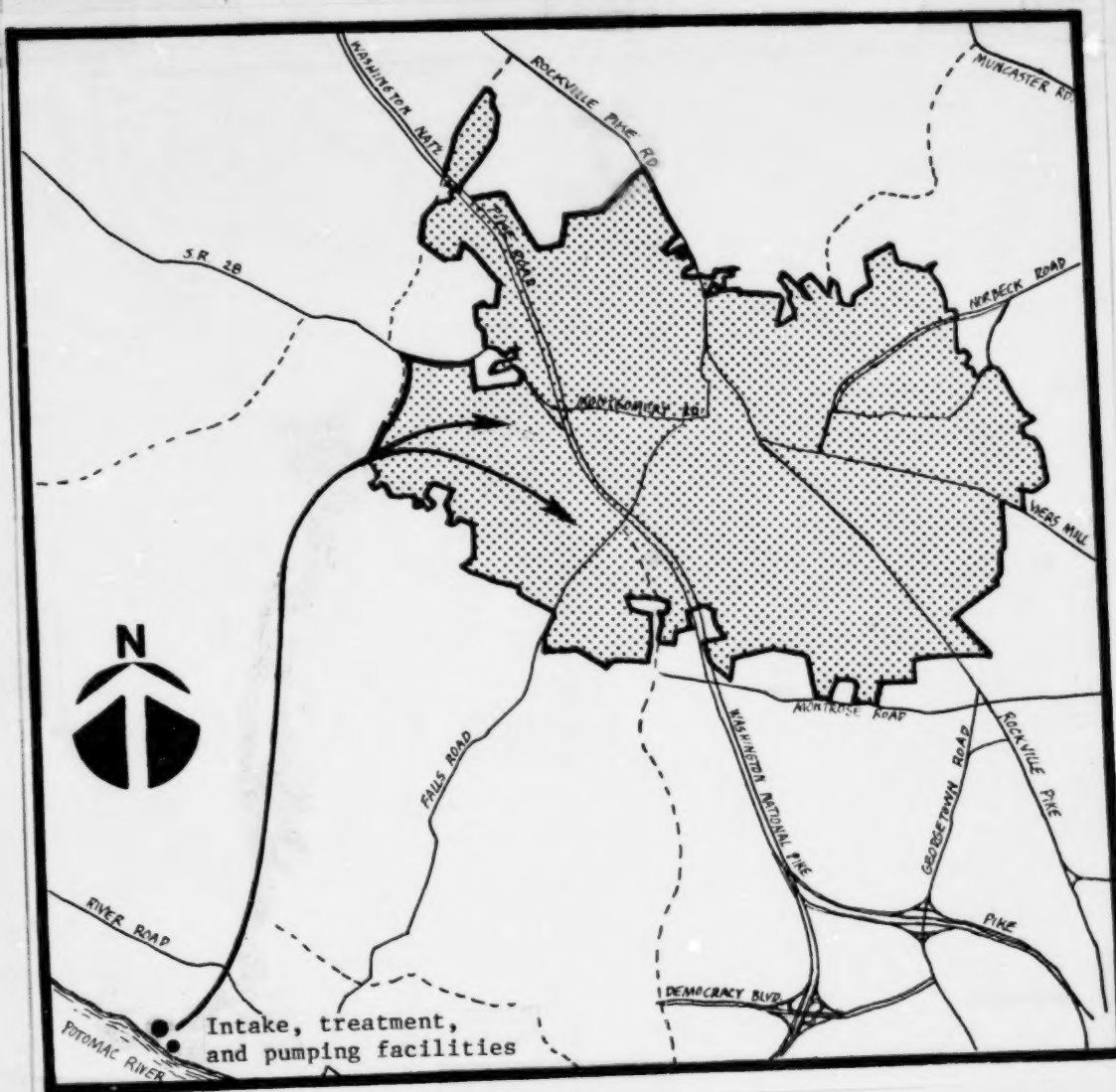
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ROCKVILLE WATER UTILITY FACILITIES MAP

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Rockville service area.

Direction of water flow.

Figure 65. Rockville Water Utility facilities map.

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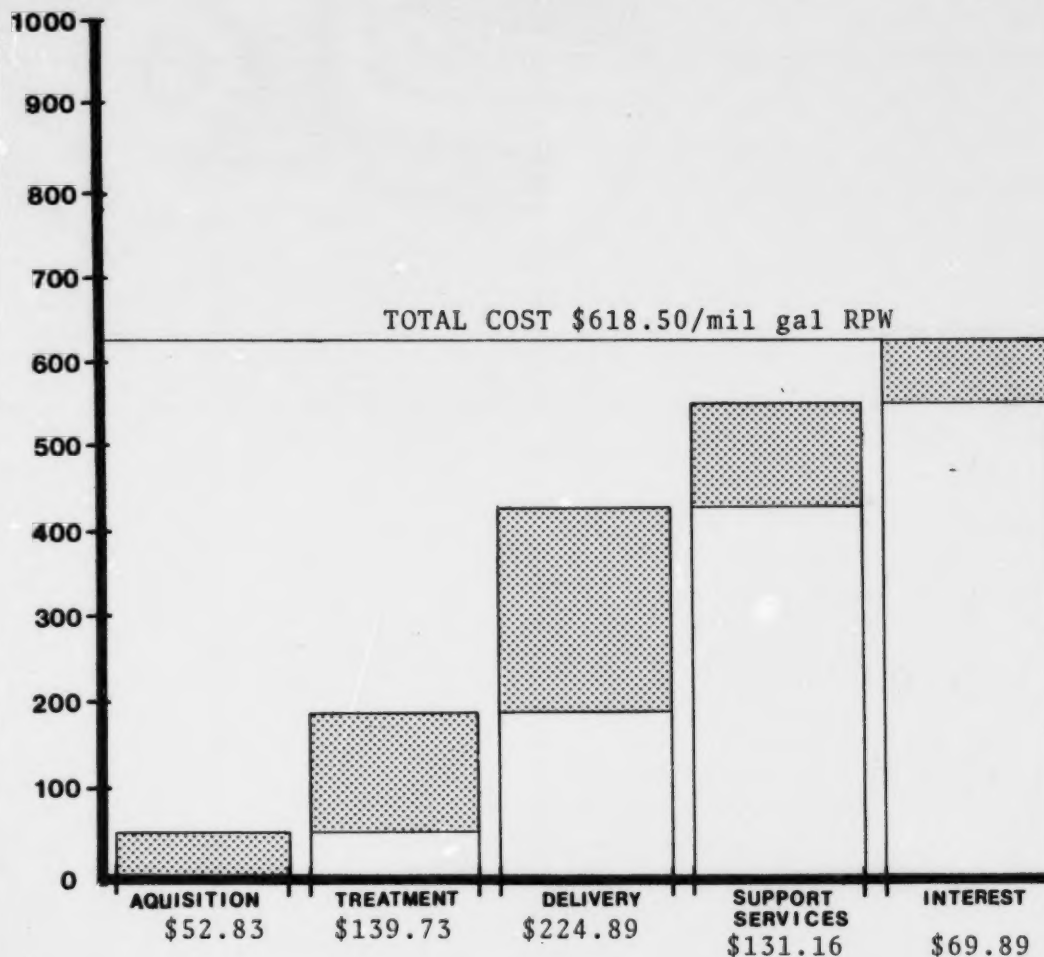


Figure 66. Rockville Water Utility allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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treatment facility. The distribution system consists of 428.5 miles of mains.

Cost Analysis

Figure 67 shows the trends in treated and revenue-producing water over the period of analysis. O&M and capital costs are summarized over the 10-year period in Table 30. Delivery, the fastest growing cost category, increased by 86 percent over the period of analysis.

Systems Evaluation

Figure 68 shows the distribution and transmission facilities for the utility. Figure 69 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Arlington County Water Supply is acquired at a cost of \$156.98/mil gal RPW. An additional \$224.43 is spent for distribution. Support services and interest costs are also added, yielding a total cost of \$499.69/mil gal of RPW.

FALLS CHURCH WATER SUPPLY

The first public water supply system in Falls Church was established in 1931. In 1934, tanks were constructed to accept the well water supply. In 1950, city wells were no longer adequate to meet increasing demands, and the city arranged to obtain water from the WAD. Water is obtained directly from the Dalecarlia plant via the crossing at Chain Bridge. The Department of Public Utilities manages, operates, and maintains the city's water and sewer systems. Falls Church also purchases a small amount of water from Arlington County to serve some of its customers located in an area too high to be served efficiently by the Falls Church system. There are also emergency connections with the Fairfax County Water Authority. The service area covers approximately 33 square miles, of which 31 square miles are in Fairfax County.

Cost Analysis

Figure 70 illustrates the growth in consumer demand for both treated and revenue-producing water over the period of analysis. As shown in Table 31 is a summary of O&M and capital costs over the 10-year period.

Systems Evaluation

Figure 71 shows the location of the facilities associated with transmission and distribution and major flow patterns in the Falls Church Water Utility. Figure 72 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves

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MILLIONS OF GALLONS

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YEARS (1967 - 1976)

Figure 67. Arlington County Water Utility water flow: treated water vs RPW.

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TABLE 30. SUMMARY OF OPERATING AND CAPITAL EXPENDITURES FOR ARLINGTON COUNTY (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	.282	.306	.327	.362	.436	.491	.382	.326	.410	.517
% of total	16.54	17.85	16.51	17.72	17.99	18.87	14.47	12.71	14.32	17.90
\$/mil gal	46.	53.	53.	58.	67.	66.	57.	47.	60.	76.
Acquisition										
million \$	.803	.796	.846	.864	1.017	1.080	1.002	1.060	1.104	1.073
% of total	47.06	46.48	42.67	40.05	41.99	41.49	37.99	41.54	38.53	37.16
\$/mil gal	132.	137.	138.	132.	155.	146.	150.	154.	162.	157.
Treatment										
million \$	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
% of total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
\$/mil gal	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Delivery										
million \$	.622	.611	.809	.911	.969	1.031	1.253	1.168	1.351	1.299
% of total	36.41	35.67	40.82	42.22	40.02	39.64	47.54	45.75	47.13	44.96
\$/mil gal	102.	105.	132.	139.	148.	139.	187.	169.	199.	190.
Total Operating Costs										
million \$	1.707	1.713	1.982	2.157	2.422	2.602	2.637	2.552	2.866	2.890
\$/mil gal	281.	296.	323.	329.	370.	351.	394.	370.	421.	423.
Depreciation										
million \$	.161	.164	.166	.169	.171	.176	.187	.231	.235	.240
Interest										
million \$	.091	.082	.075	.068	.134	.195	.221	.207	.225	.287
Total Capital Costs										
million \$										
Total Operating and Capital Costs										
million \$	1.960	1.958	2.224	2.394	2.726	2.974	3.045	2.991	3.326	3.417
\$/mil gal	322.	338.	362.	366.	417.	401.	455.	434.	489.	500.

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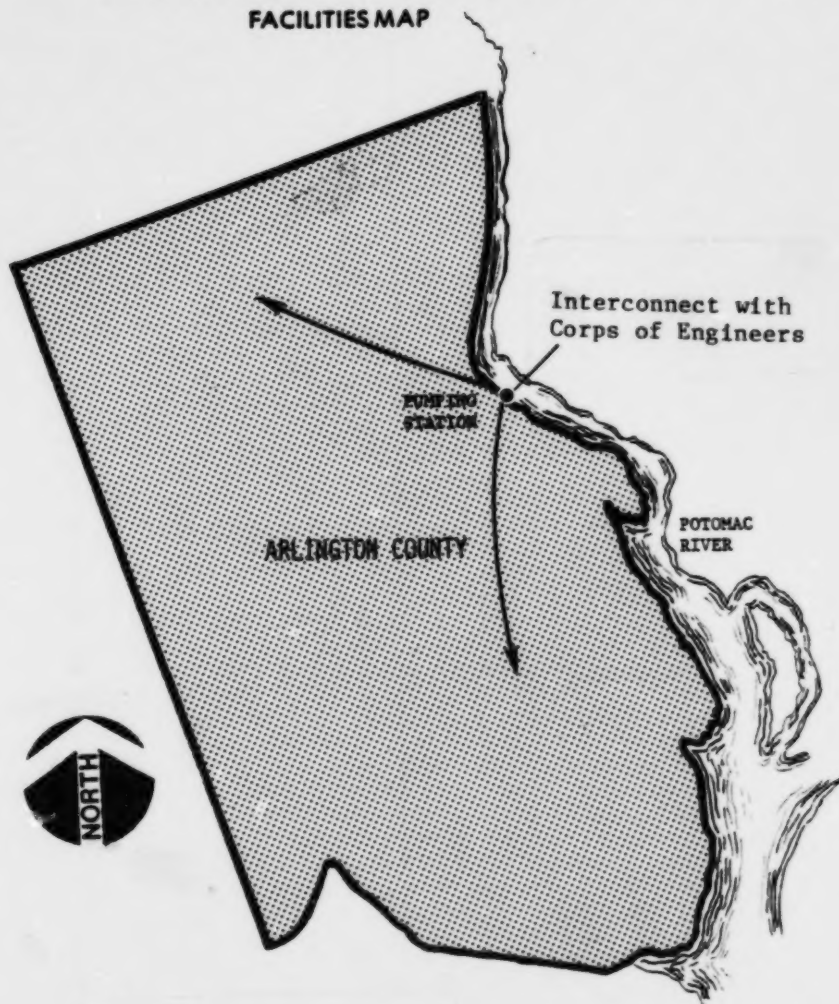
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ARLINGTON COUNTY WATER SUPPLY FACILITIES MAP



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Figure 68. Arlington County facilities map.

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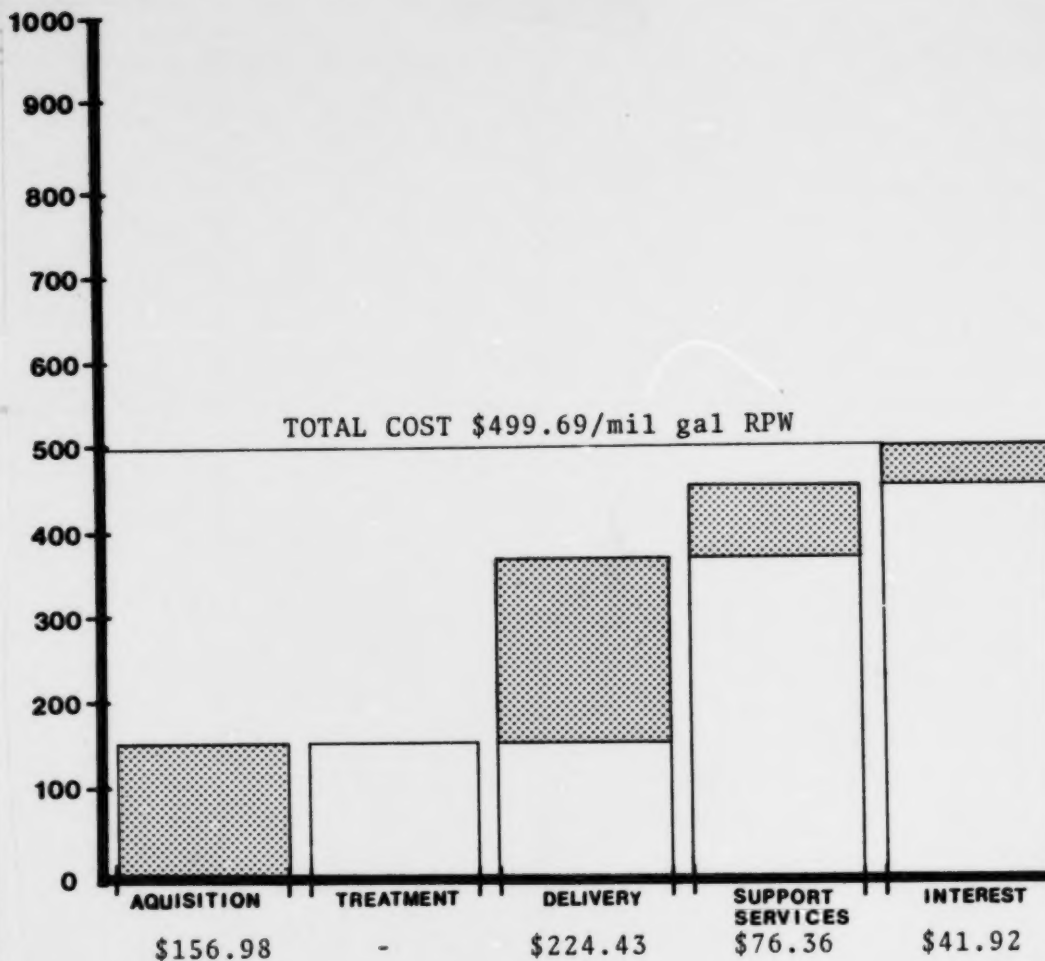


Figure 69. Arlington Water Utility allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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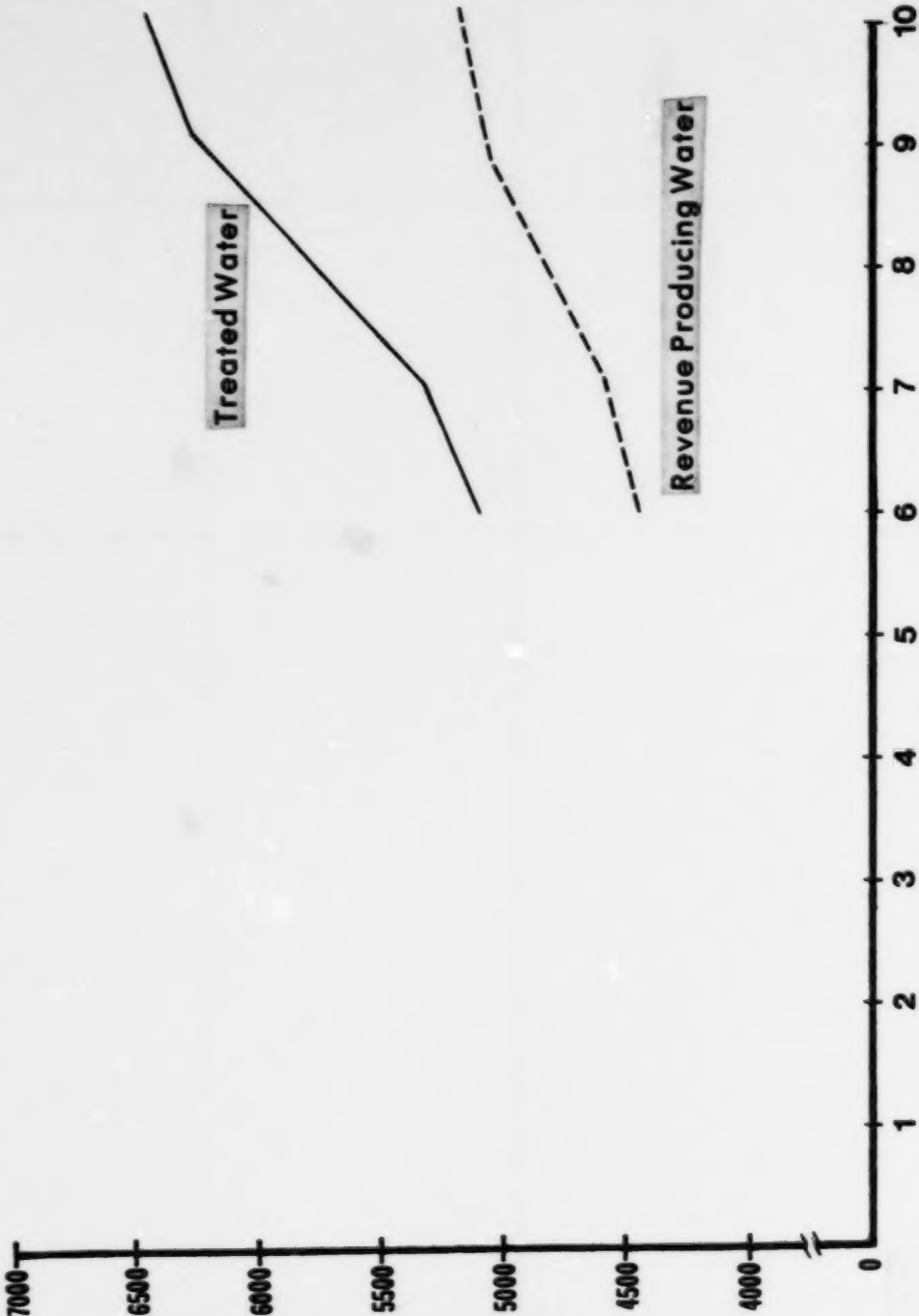
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YEARS (1967 - 1976)

Figure 70. Falls Church Water Utility water flow: treated water vs RPW.

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TABLE 31. SUMMARY OF OPERATING & CAPITAL EXPENDITURES FOR FALLS CHURCH (1967 - 1976)

Items	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	--	--	--	--	--	.438	.467	.534	.563	.652
% of total	--	--	--	--	--	28.00	28.00	28.00	28.30	30.15
\$/mil gal	--	--	--	--	--	98.	102.	110.	110.	126.
Acquisition										
million \$	--	--	--	--	--	.688	.734	.839	.873	.956
% of total	--	--	--	--	--	44.00	44.00	44.00	43.90	44.23
\$/mil gal	--	--	--	--	--	154.	161.	174.	171.	185.
Treatment										
million \$	--	--	--	--	--	.0	.0	.0	.0	.0
% of total	--	--	--	--	--	0.00	0.00	0.00	0.00	0.00
\$/mil gal	--	--	--	--	--	0.	0.	0.	0.	0.
Delivery										
million \$	--	--	--	--	--	.438	.467	.534	.552	.554
% of total	--	--	--	--	--	28.00	28.00	28.00	27.80	25.61
\$/mil gal	--	--	--	--	--	98.	102.	110.	108.	107.
Total Operating Costs										
million \$	--	--	--	--	--	1.563	1.668	1.907	1.988	2.162
\$/mil gal	--	--	--	--	--	350.	365.	394.	390.	419.
Depreciation										
million \$	--	--	--	--	--	.192	.207	.264	.220	.227
Interest										
million \$	--	--	--	--	--	.148	.147	.140	.146	.131
Total Capital Costs										
million \$	--	--	--	--	--					
Total Operating and Capital Costs										
million \$	--	--	--	--	--	1.903	2.022	2.291	2.353	2.520
\$/mil gal	--	--	--	--	--	426.	443.	474.	462.	488.

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FALLS CHURCH WATER SUPPLY FACILITIES MAP



Figure 71. Falls Church Water Supply facilities map.

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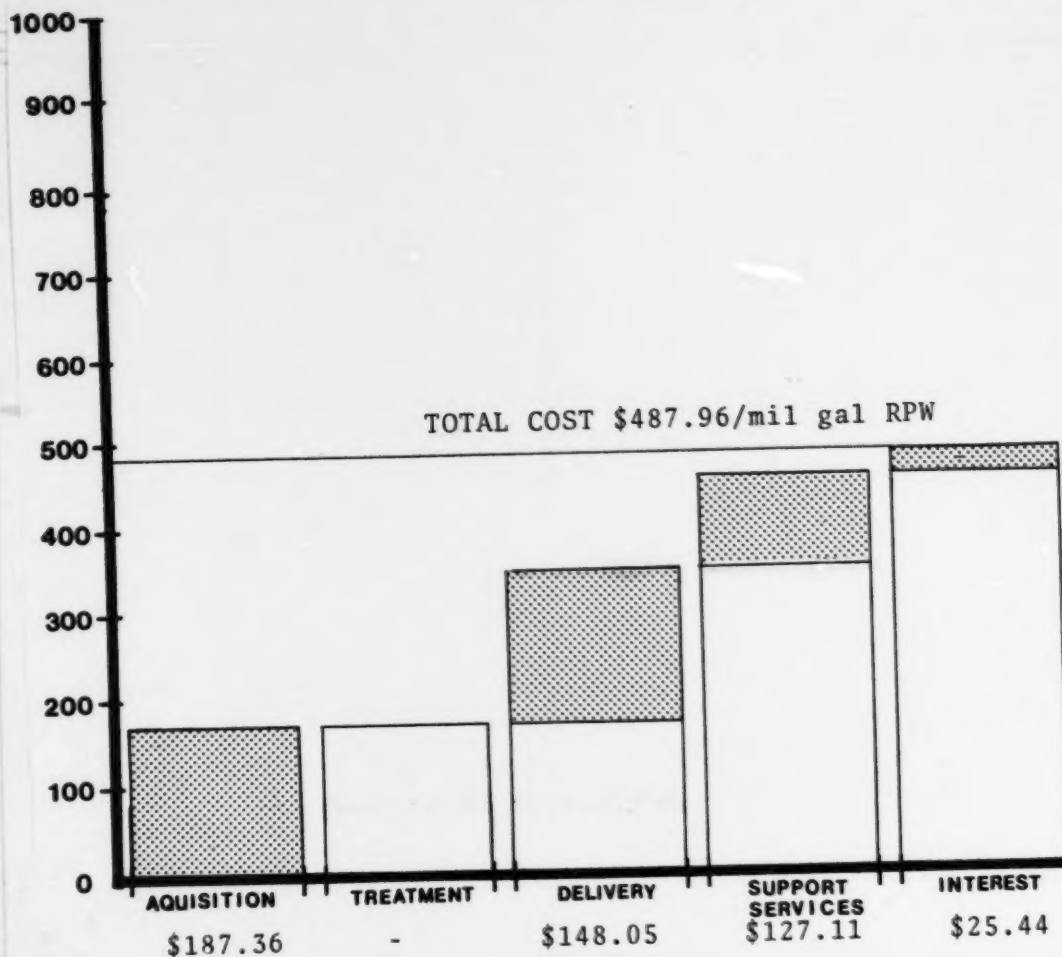


Figure 72. Falls Church Water Supply allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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from one functional cost center to the other.

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For example, water for the Falls Church Water Supply is acquired at a cost of \$187.36/mil gal RPW. An additional \$148.05 is spent for distribution. Support services and interest costs are also added, yielding a total cost of \$487.96/mil gal of RPW.

LEESBURG WATER UTILITY

The Town of Leesburg, Virginia, owns and operates the public water supply and distribution system. Water is acquired from six drilled wells. The distribution system of the Leesburg Water Utility consists of approximately 28.9 miles of 2- to 12-inch pipes.

Cost and Systems Analysis

Figure 73 shows the growth in water production over time. Table 32 shows operating, maintenance, and capital costs for the period of analysis. Figure 74 shows the facilities and flow pattern associated with water distribution in the utility. Figure 75 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Leesburg Water Utility is acquired at a cost of \$149.86/mil gal RPW. An additional \$34.86 is spent on the treatment of the water, as is \$458.50 for distribution. Support services and interest costs are also added, yielding a total cost of \$908.50/mil gal of RPW.

COMPARATIVE COST EVALUATION

Table 33 shows the deficits from 1980 through 2050 for the 1930, 1932, and 1966 flow conditions. These deficits illustrate the problem which provides the driving force for taking action that will ultimately result in increased cost to the consumer. The three possible strategies that may be considered for increasing available source water in the Potomac are: construction of reservoirs, building of renovated wastewater treatment plants, or construction of interconnections. Table 34 shows some of the cost increases that will occur from adopting various augmentation strategies assuming 1930 river flow conditions. Column 1 is the current cost for acquisition and column 2 is the new acquisition costs associated with adoption of a given strategy. For example, constructing a reservoir will increase the cost of water supply to WSSC from \$566/mil gal to \$578/mil gal, a 2.1 percent increase (column 4). The average cost of increased augmentation through the end of the planning cycle (based on 1976 costs) were calculated and used as the new acquisition cost. Columns 5 through 8 show the existing cost of treatment and the projected cost of other types of add-on technology that may be required to meet the

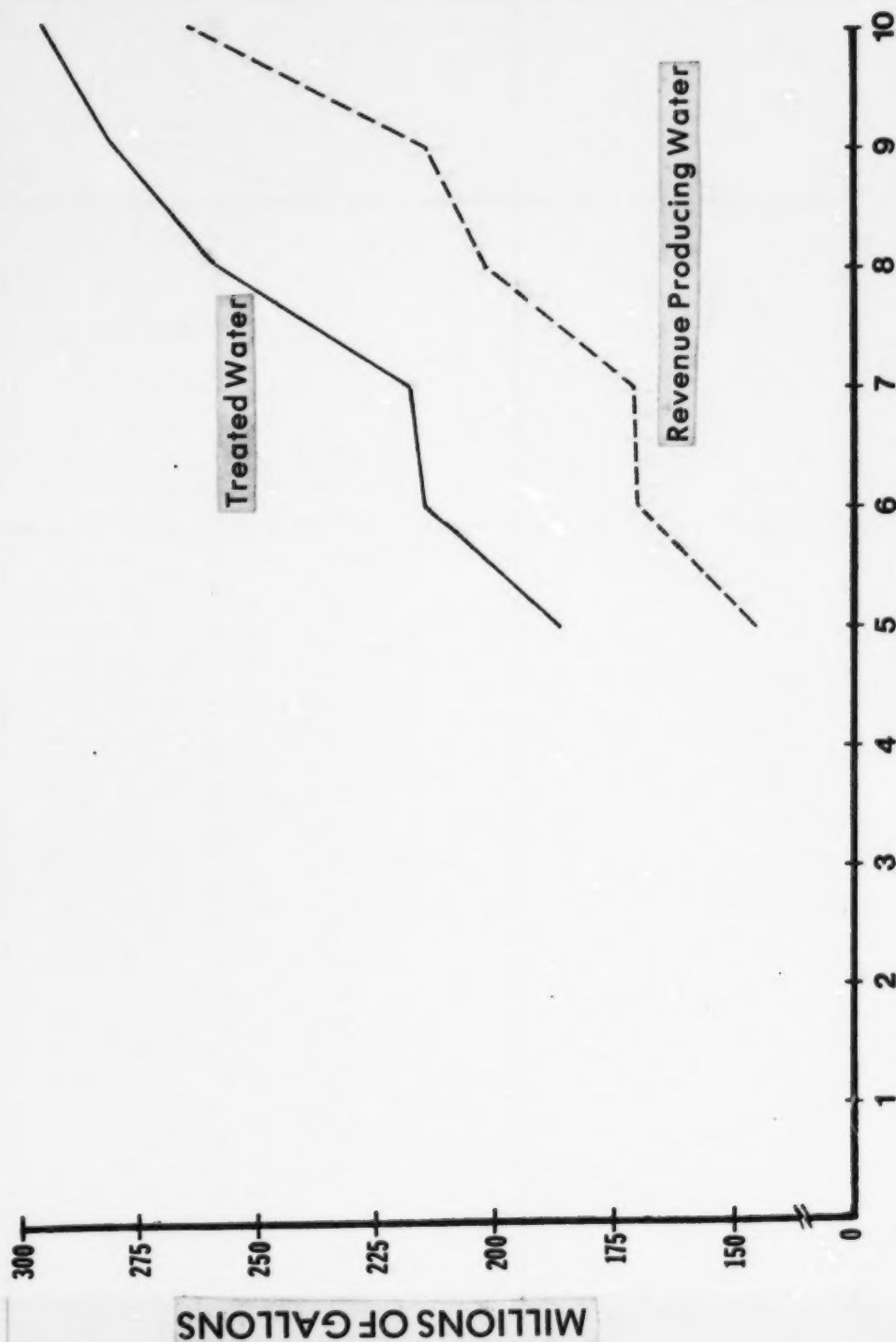
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YEARS (1967 - 1976)

Figure 73. Leesburg Water Utility: treated water vs. RPW.

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TABLE 32. SUMMARY OF OPERATING & CAPITAL EXPENDITURES FOR LEESBURG (1967 - 1976)

Item	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Support Services										
million \$	--	--	--	--	.001	.002	.001	.001	.013	.033
Σ of total	--	--	--	--	1.63	4.40	1.50	1.28	12.32	21.86
\$/mil gal	--	--	--	--	4.	13.	6.	5.	58.	126.
Acquisition										
million \$	--	--	--	--	.006	.007	.008	.021	.020	.039
Σ of total	--	--	--	--	15.82	12.95	12.38	26.60	19.13	25.43
\$/mil gal	--	--	--	--	40.	39.	48.	105.	90.	146.
Treatment										
million \$	--	--	--	--	.002	.003	.003	.005	.006	.008
Σ of total	--	--	--	--	5.61	5.20	5.17	5.35	5.50	5.40
\$/mil gal	--	--	--	--	14.	16.	20.	23.	26.	31.
Delivery										
million \$	--	--	--	--	.029	.039	.054	.059	.065	.072
Σ of total	--	--	--	--	76.94	77.45	80.95	68.77	63.05	47.31
\$/mil gal	--	--	--	--	196.	232.	312.	292.	297.	272.
Total Operating Costs										
million \$	--	--	--	--	.037	.051	.066	.086	.103	.153
\$/mil gal	--	--	--	--	255.	300.	385.	425.	472.	575.
Depreciation										
million \$	--	--	--	--	.051	.051	.052	.052	.052	.052
Interest										
million \$	--	--	--	--	.041	.041	.041	.043	.040	.037
Total Capital Costs										
million \$	--	--	--	--						
Total Operating and Capital Costs										
million \$	--	--	--	--	.129	.143	.159	.180	.194	.242
\$/mil gal	--	--	--	--	883.	839.	925.	893.	892.	910.

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LEESBURG WATER UTILITY FACILITIES MAP

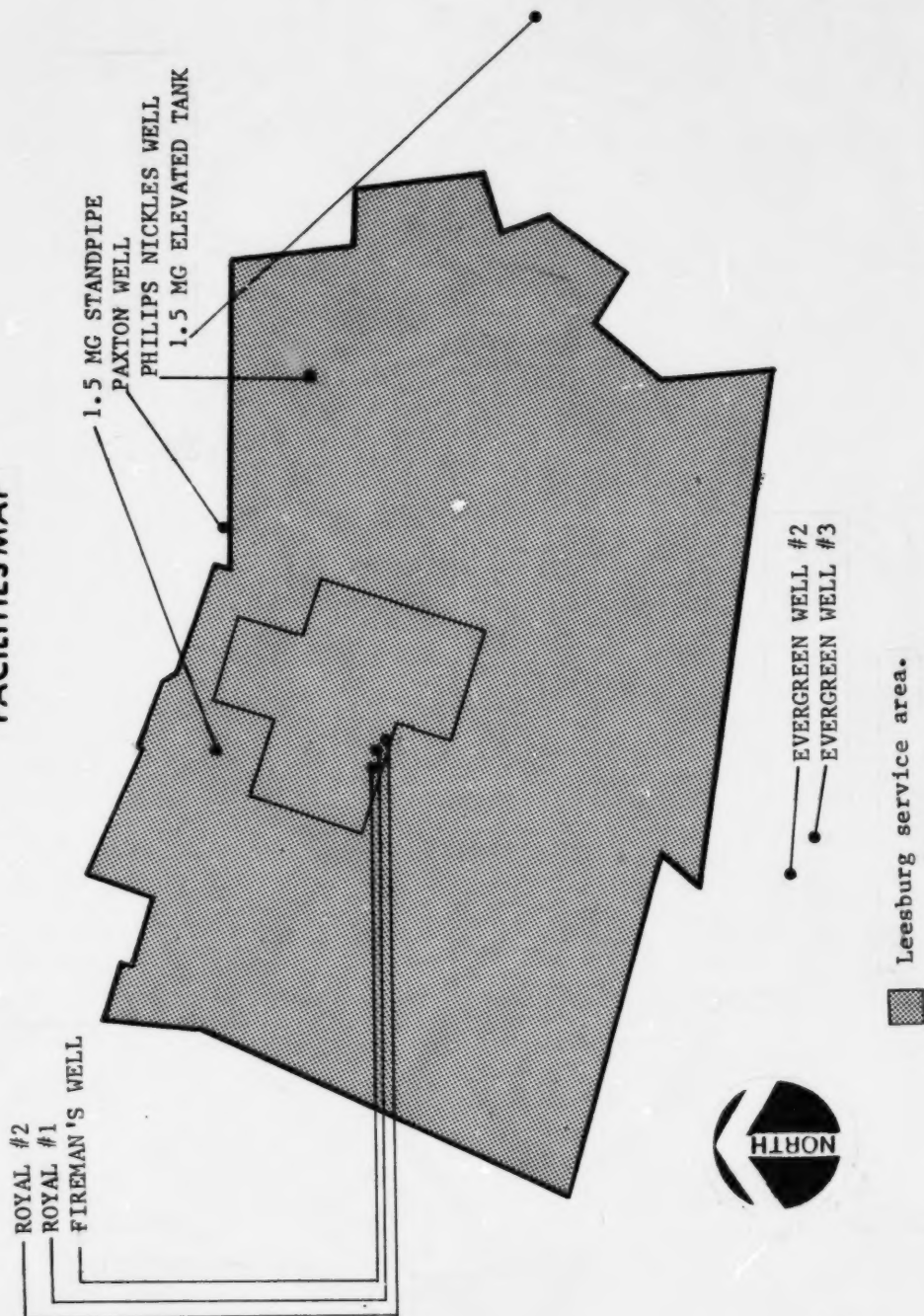


Figure 74. Leesburg Water Utility facilities map.

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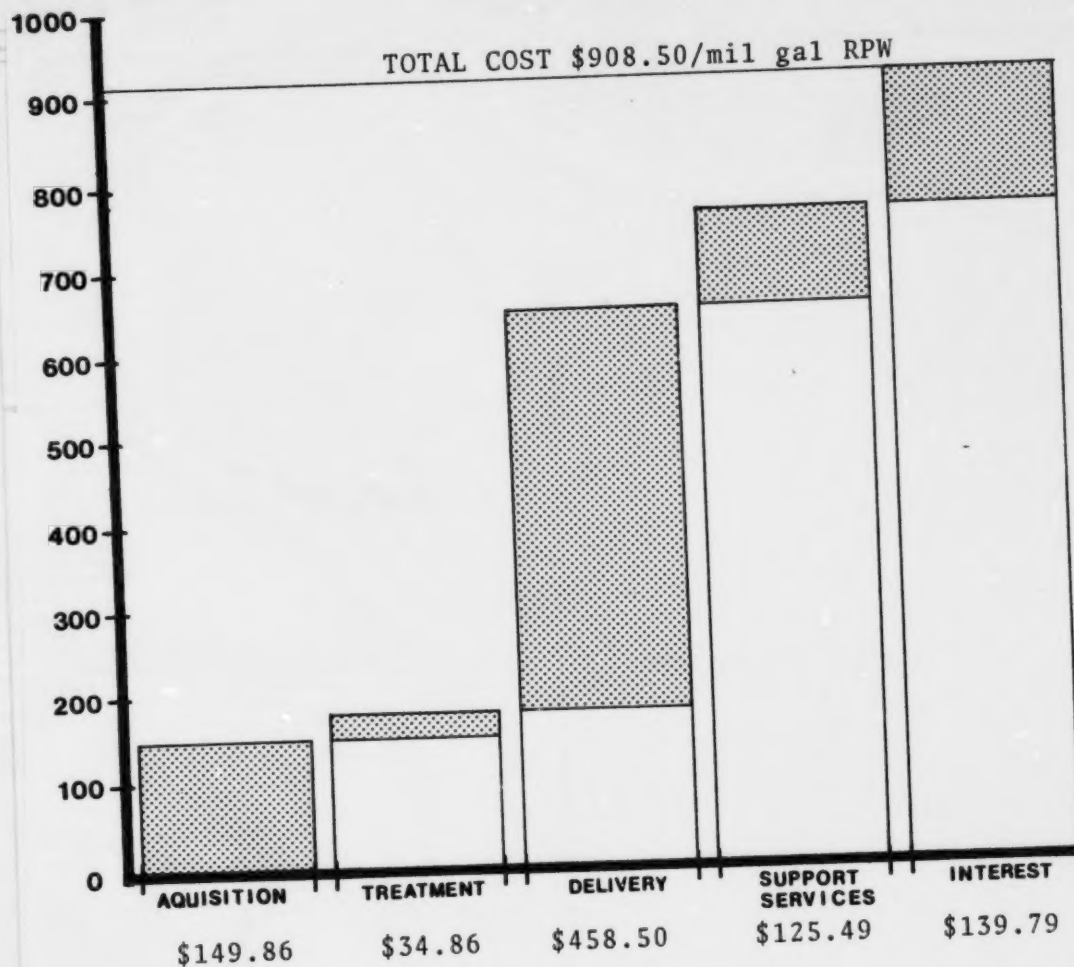


Figure 75. Leesburg Water Utility allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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TABLE 33. MAGNITUDE OF YEARLY DEFICITS (MG)

	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
WITHOUT CONSERVATION: OTHER WMA WATER, 2-DAY STORAGE															
1930	-	-	2258	7169	11615	16356	21322	26895	31595	38235	43736	50692	56725	62686	68768
1932	-	-	-	109	855	1703	2578	3552	4984	7043	9067	12067	14842	17562	20394
1966	-	407	1863	3867	5586	7603	9949	12482	14512	17382	20089	23584	26657	29833	33029
WITHOUT CONSERVATION: OTHER WMA WATER, 2-DAY STORAGE, BLOOMINGTON ADDED															
1930	-	-	-	-	189	2093	6363	11393	15840	22388	27781	34559	40665	46582	52576
1932	-	-	-	-	-	-	-	188	857	1874	2707	4158	6032	8449	11193
1966	-	-	-	-	623	2089	3771	5646	7425	10272	12602	15646	18711	21878	25074
WITH CONSERVATION: OTHER WMA WATER, 2-DAY STORAGE, BLOOMINGTON ADDED															
1930	-	-	-	-	-	-	-	-	-	-	49	927	1458	1938	2655
1932	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	177	496	1266	1641	1985	2334

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TABLE 34. WASHINGTON AREA UTILITY COST SUMMARY (\$/mil gal) 1930 RIVER FLOW CONDITIONS

	column:	1	2	3	4	5	Assumed				Percent Increase				Total with Acqui-				Percent Increase																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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							cost in cost of water supply	cost	Chlorine	Ozone	GAC*	Dioxide	Chlorine	Ozone	GAC*	Dioxide	Chlorine	Ozone	GAC*	Dioxide	Chlorine	Ozone	GAC*	Dioxide																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
MSSC RESERVOIR RW INTERCONNECTS	15		566	2.1	122	123	127	266	0.8	4.1	85.2		579	583	682	2.3	3.0	20.5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

* GAC - Granulated Activated Carbon

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requirements of the Safe Drinking Water Act. Obviously, not all the types of treatment will be required at each utility, but these costs will give some idea of ranges in cost that may be incurred to meet the Act's requirements. Columns 9 through 11 show the percent increase in treatment cost associated with the three specific treatment types. Columns 12 through 14 contain the new totals for both acquisition and the add-on treatments, and columns 15 through 17 show the percent increase above current costs for both the new acquisition and the new, hypothetical treatment. Appendix G provides additional information in this area.

The same logic can be used for the other three utilities shown in Table 34. Arlington and Falls Church were not included since they acquire their water, already treated, from WAD and their impact is reflected in the D.C. system. Leesburg was excluded because they presently use ground water and their changing to surface water will involve intakes and treatment facilities which will change their cost base.

Another important consideration is the comparative cost evaluation of the various augmentation alternatives. These costs are summarized in Figure 76. The total cost for each alternative is plotted versus deficit capacity satisfied. This figure provides some indication of the relative capacity of each alternative. The equations for the annual cost of each augmentation alternative are as follows:

$$\text{Reservoir} \quad Y = .07 \times C^{.76}$$

$$\text{RWW} \quad Y = .20 \times C^{.94}$$

$$\text{Interconnects} \quad Y = .07 \times C^{.92}$$

Y= annual cost
C= capacity in mil gal

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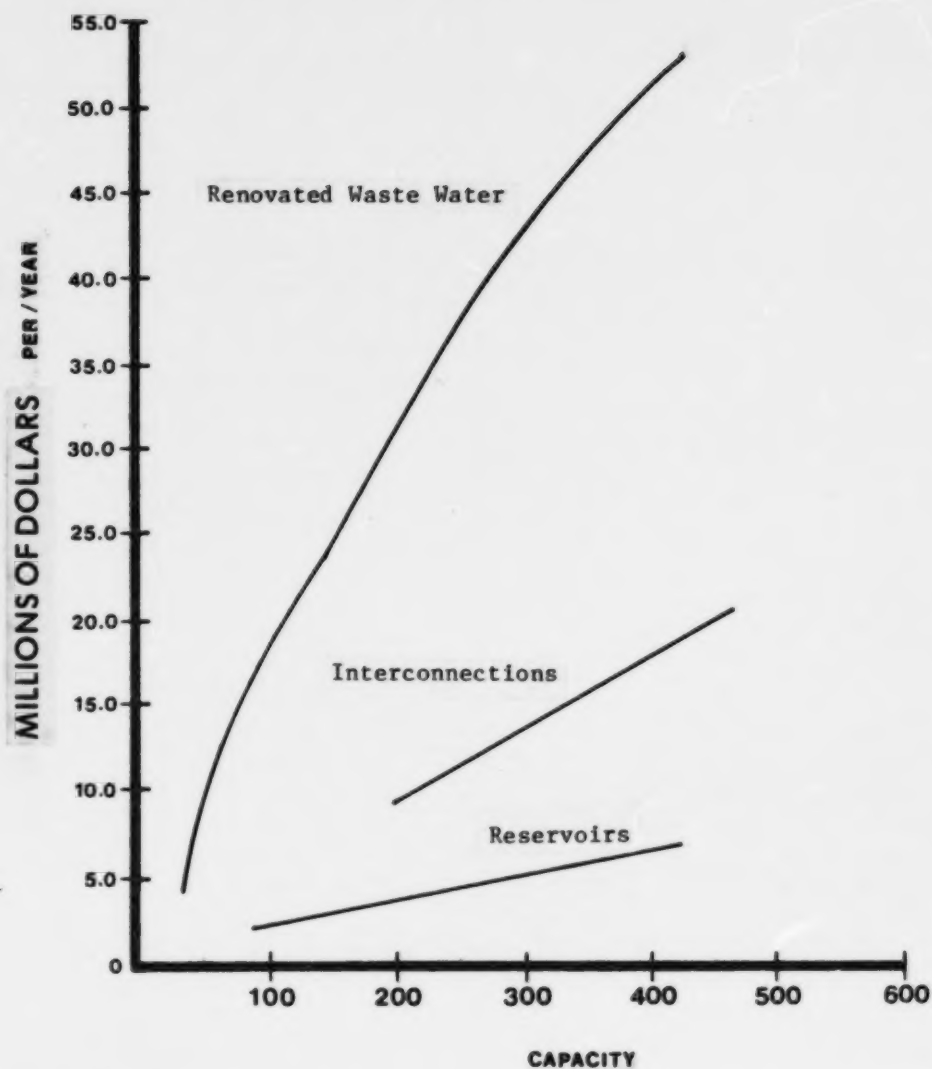


Figure 76. Annual cost versus capacity of supply augmentation options.

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SECTION 9

REFLECTIONS

The analysis in the previous sections was based on a quantitative evaluation of the data collected during the course of the study. However, numbers tell only part of the story, and the complex interaction of the various institutions involved in water supply in the WMA defies quantification. The only way that their interaction can be properly assessed is by subjective evaluation. In this section, the investigators have attempted to pool their observations and to make these subjective evaluations of the WMA water supply problem. As such, this section reflects the authors' opinion only and no attempt is made to substantiate it through empirical verification.

The investigators were left with several strong impressions as a result of this study. These impressions centered primarily around the problems with the D.C.-DES system, and the strong feelings on the part of the WMA utilities to seek individual rather than regional solutions. (35, 36)

From a water supply point of view, the investigators found that the D.C. Department of Environmental Services (D.C.-DES) was a difficult organization from which to collect valid water supply cost and operational data. Difficulties were encountered in several areas as follows:

1. The D.C.-DES organization is fragmented and difficult to define. It appears to be functionally oriented, with many or all of the individuals who perform management functions for water supply also performing the same functions for other programs. Generally, it was necessary to see three or four people in order to reach someone who could and would provide specific water supply data elements.
2. The accounting documentation for water costs is apparently integrated with other functions. The investigators were unable to see any of the financial records but, were eventually provided with a table that identified water supply costs during the last 10 years of operation. No background data were provided relating to the validity of the table. In general, the basic response to our requests for O&M costs was to be presented with a table of budgeted expenditures.
3. Several individuals within the organization referred to meter reading taking place within the district. However, we were not able to obtain any recent meter readings. Based on articles that

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appeared in local newspapers and remarks made by D.C.-DES personnel indicating that meters have not been read in two years, it is obvious that meter reading is not done regularly. D.C.-DES did have a single sheet of paper that identified water consumption corresponding with the water releases reported by the Corps of Engineers (COE) from the treatment plant. Several of the values were marked by an asterisk, which referred to a note stating that the figures were estimated based on previous values; the same note referred to previous values. Again, the estimates were traceable to 1968, the last year for which documentation was obtained.

4. Operation of the DC-DES is funded by an appropriation from Congress and is not dependent on revenues derived from the water sold. Thus, justification of the budget is more important than collection of revenues.
5. The water supply system serving D.C. is not only fragmented internally, but the function is actually accomplished by two organizations. The acquisition and treatment of water are accomplished by the COE. Corps personnel talk about providing water to Arlington, Falls Church, and other users outside the District. DC-DES also talks about providing water to the same customers and shows this water as coming from their water system. There appears to be some confusion as to what the system is and who operates it. The first analysis effort addressed D.C.-DES as two independent systems, with the two computer printouts balancing with COE and D.C.-DES financial records, respectively. The system was then combined into one total system, integrating the financial and operational records of COE and D.C.-DES to produce a single computer printout. This public water supply for D.C. record will reflect the total system cost, but will not balance to either COE or DC-DES individual financial and operational records. For example, the RPW of the COE and D.C.-DES was considerably different. Therefore, the cost per mil gal of RPW for acquiring water would be a different value than the COE would recognize because it would be based on the DC-DES value rather than on their own value.

INDIVIDUAL SOLUTIONS

Water utilities within the WMA believe that the solution to the future water needs of the area can best be handled by each individual utility and not on an areawide basis. In fact, one of the major water purveyors in the area continually challenged even the existence of a problem. Based on our study of future population growth and distribution and examination of alternative source water to meet future demands, the Potomac River appears to be the major focal point for obtaining additional water supply. Since large portions of the population in the WMA on both sides of the Potomac are supplied by the Potomac, and since future plans of all of the major water utilities include additional withdrawals from the Potomac, the ability to maintain the flow level becomes critical. During times of minimum flow, the allocation of water is highly important.

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There is a basic paradox that exists concerning the individual utilities' public stance that there is no problem or that if there is one it must be solved by individual solutions. This paradox is illustrated by the Low Flow Agreement for the Potomac. All of the utilities who deny either the need for a regional solution and the existence of a problem, have signed the Agreement, yet by signing the Agreement they have admitted that both needs exist. This inconsistency is a perfect illustration of the kind of problems that exist in the D.C. area.

The analysis showed that careful management of the release of water from upstream reservoirs will provide the maximum amount of water for the minimum cost. It is necessary to correlate the release with river flow and users demand. Even if renovated wastewater is used to supplement the river flow, it is still desirable that the river flow be carefully managed and correlated with all utilities' withdrawals. It is the investigators' opinion that the ultimate solution to the future water demands for the WMA can best be resolved through an area-wide approach.

Another possible solution to the WMA water supply problem lies to the north. Future water shortages in the Baltimore area may not be as critical as potential Washington Metropolitan Area shortages. A raw water interconnection as short as 20 miles in length between the Patapsco River and Patuxent could be used by WSSC to relieve demands on the Potomac under drought conditions. The key question that must be answered involves the time phasing of low flow conditions within the two systems. To the investigators' knowledge this possibility has not been explored. A superficial analysis of flows in the Potomac and Deer Creek, has been performed. See Appendix F for more detail.

It is the investigators' opinion that the Bloomington Reservoir will provide adequate water until the year 2000 if the water release pattern is carefully managed and if there are no drought conditions worse than those that occurred between 1900 and the present. However, there is no guarantee that a drought of greater severity will not occur and drastically reduce the source water available to the WMA. This condition, along with a non-optimal release pattern and a low initial reservoir level at Bloomington, could pose a major problem. The risk of a drought situation increases each year as demand increases. Initially, there will be some reserve of water in the reservoir after known drought conditions are met. However, as the year 2000 approaches, less and less reserve will be available for meeting demands.

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SECTION 10

SUMMARY AND CONCLUSIONS

Water supply problems in the WMA are diverse and complex, and represent problems of political interaction as much as actual shortages in water availability. The diversity of constituencies and goals of each of the water suppliers in the WMA represent a significant part of the WMA water supply problem. One striking result of this study was the observation that, for a water-short area, there seems to be little consistency on the part of the individual utilities as to how consumers are identified. Each utility has widely different definitions of water use categories, as well as significant differences in prices charged for the water use. This lack of consistency is especially noticeable within the Washington D.C.-DES. Many of the non-residential customers for water in D.C.-DES are housed in older government buildings. The buildings may have one pass-through cooling systems, but the utility itself has little knowledge of its customers' water-using characteristics. There appears to be confusion as to when, if ever, the meters for these buildings are read.

Customer billing in D.C.-DES is sporadic and confusing. There are instances of customers receiving bills of several thousand dollars, either as "catch-up" bills or because of mistakes in billing.

An analysis of future water deficit problems clearly shows that although current water shortage possibilities are minimal, a significant risk of future water shortages exists. Therefore, one immediate action that could be taken by all the utilities that are withdrawing or planning to withdraw water from the Potomac would be to develop a standard accounting procedure for water supply. Such a system would encompass development of standard terminology for defining water use categories. These definitions could be worked into a chart-of-accounts for assessing costs to various customer classes within the WMA. The system should be based on both product and responsibility accounting techniques. Responsibility accounting is the standard approach toward cost accounting in which costs are assigned to organizational units. Product costing provides information on the costs associated with water delivered to specific points within the water service area. Such information would help water utility managers make more efficient decisions regarding the choice of future water augmenting alternatives, such as reservoirs, interconnections, etc.

Superficially, conservation appears to be the ideal solution to the water supply problem in the WMA. Certainly, conservation based on the

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assumption in this report would allow for ample water supplies through 2020. However, implementing conservation is easier said than done, and a conservation program should also include an understanding of where water is currently going and how much it costs to get it there. As shown in this analysis, much of the conservation could be accomplished by installing water conserving devices in new homes, businesses, and, with some retrofitting, in existing homes. Certainly, conservation has some advantages in that it has minimal environmental impact. But, even with water conserving devices, conservation may be difficult to ensure. In addition, water conservation is not cheap and, as shown, could be an expensive alternative for the consumer.

Reservoirs provide a possible solution to WMA water problems. The construction of Bloomington has gone a long way toward alleviating possible problems. Proper release patterns might be developed to solve any severe drought conditions such as those that occurred in 1930 and 1966. However, there has been a strong public reaction against the construction of reservoirs and this analysis supports the idea that the extensive reservoir proposals contained in the NEWS study are unjustified.

Interconnections have been a popularly discussed solution for WMA problems but, as can be seen, their capacity to solve the problem is limited and eventually some other action must be taken. Interconnections are expensive and will cause severe local environmental impact due to construction of large transmission lines.

Renovated wastewater is extremely expensive as a solution. In addition, unsolved health problems are associated with RWW effluent. If the requirements for wastewater discharge approach drinking water standards, then RWW might be a feasible solution.

As can be seen from the deficit analysis, current risks of a water shortage are low, but will rise significantly over the next 50 years, assuming current population growth trends. The water utilities should develop and institute a cost accounting and tracking system for water supply. This system should be based on a common definition for water use categories, and should include elements of responsibility and product costing. The accounting system could be the cornerstone for a conservation policy, which should include installation of water conserving devices in new homes and places of business and reduction of water use in existing facilities wherever possible.

Water use should be monitored closely, and flow-monitoring devices that allow more accurate release patterns from the Bloomington reservoir should also be developed to better match water demands and river flows.

Finally, although controversial, consideration should be given to the eventual construction of an additional reservoir to stabilize Potomac flow. It is the authors' opinion that interconnections, although apparently attractive, are expensive and potentially damaging to the environment, and are limited in capacity. Finished water interconnections could

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be encouraged to spread the peak demand. Unless effluent discharge standards rise dramatically, wastewater reuse will never provide an economic solution to the WMA water problems. The possibility of an emergency link to the Baltimore water supply should be explored.

Above all, it is the authors' opinion that the biggest problem in the WMA is political. For example, on the one hand some of the major utilities deny the existence of a problem or the need for regional solutions, but on the other hand acknowledge that there is a problem and that regional action needs to be taken to solve them. This paradox is illustrated by the fact that all the utilities have signed the Potomac Low Flow Agreement. We believe that short-term problems can be solved with minimal cost and difficulty, but not under present conditions wherein everyone is involved in the problem, some do not admit that it exists, and no one feels responsible for the solution.

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APPENDIX A
POTOMAC RIVER LOW FLOW ALLOCATION AGREEMENT
OF 11 JANUARY, 1978

THIS AGREEMENT, made and entered into this 11th day of January 1978, by and among the UNITED STATES OF AMERICA (hereinafter called "the Government") acting by the Secretary of the Army through the Chief of Engineers, the STATE OF MARYLAND (hereinafter called "the State") acting by the Governor and the Secretary of the Department of Natural Resources, the COMMONWEALTH OF VIRGINIA (hereinafter called "the Commonwealth") acting by the Governor and the Chairman of the State Water Control Board; the DISTRICT OF COLUMBIA (hereinafter called "the District") acting by its Mayor, the WASHINGTON SUBURBAN SANITARY COMMISSION (hereinafter called "the Commission") acting by its Chairman; and the FAIRFAX COUNTY WATER AUTHORITY (hereinafter called "the Authority") acting by its Chairman;

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PREFACE

WHEREAS, the Chief of Engineers is charged with the operation and maintenance of the Washington Aqueduct for the primary purpose of providing an adequate supply of potable water for distribution to and consumption by the agencies and instrumentalities of the Government situate in the District of Columbia and its environs, and thereafter of providing a public water supply for the inhabitants of the District of Columbia; and

WHEREAS, the Secretary of the Army is authorized, subject to certain conditions, to supply treated water from the Washington Aqueduct to any competent state or local authority in the Washington Metropolitan Area in Virginia, and to that end has entered into agreements with the County of Arlington and the City of Falls Church, Virginia; and

WHEREAS, the sole source of raw water treated by the Washington Aqueduct and dispensed therefrom is the Potomac River, and the Washington Aqueduct is now maintaining intake facilities for this purpose at Little Falls and Great Falls, Maryland; and

WHEREAS, the State of Maryland has enacted an appropriation permit statute which requires that all non-exempt jurisdictions obtain a permit from the Water Resources Administration of the State's Department of Natural Resources (hereinafter called "the Administration") to appropriate or use the water of the Potomac River; and

WHEREAS, the parties to this Agreement recognize that other riparian

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interests, such as communities located in Virginia, may in the future desire to withdraw and use water from the segment of the Potomac River which is the subject of the within Agreement, and provision is made herein requiring that access by any of them to such water be made subject to the provisions of this Agreement; and

WHEREAS, the Commission is charged with the responsibility of providing a safe and adequate public water supply within the Counties of Montgomery and Prince Georges, Maryland and is also authorized to enter into agreements to provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, the Commission maintains a water treatment plant and an intake therefrom on the Potomac River, which intake is upstream from the Washington Aqueduct intakes and within the limits of the River covered by this Agreement, and in addition the Commission maintains a water treatment plant with intake on the Patuxent River, and requires water from both sources in order to fulfill its above-mentioned responsibilities for providing a public water supply; and

WHEREAS, the City of Rockville, Maryland, is operating and maintaining water treatment facilities and a water distribution system and maintains an intake facility about one mile upstream from Great Falls on the Potomac River, which intake is upstream from the Washington Aqueduct intakes and within the limits of the River covered by this Agreement; and

WHEREAS, the Fairfax County Water Authority is an authority in the Commonwealth of Virginia proposing to withdraw water from that portion of the Potomac River which is covered by this Agreement and has applied for a permit to construct a water intake structure for such purpose; and

WHEREAS, in the absence of adequate upstream impoundments and associated flow regulation, the quantity of water which may flow in the Potomac River between Little Falls Dam and the farthest upstream limit of the pool of water behind the Chesapeake and Ohio Canal Company rubble dam at Seneca, Maryland, during periods of low flow in that portion of the River, may be less than the quantity needed to meet the demand for all customary public water supply purposes during such periods; and

WHEREAS, in light of the Federal legislative enactments providing for the Corps of Engineers to supply water to the District of Columbia, enactment of legislation was deemed by the Government to be a prerequisite to its participation in a Potomac River Low Flow Allocation Agreement; and

WHEREAS, the consent of Congress to a Potomac River Low Flow Allocation Agreement is expressly stated in Section 181 of the Water Resources Development Act of 1976, Public Law 94-587; and

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WHEREAS, the consent of Congress, pursuant to Section 9 of the Rivers and Harbors Act of 1899, to the construction of a water diversion structure by the Commission from the north shore of the Potomac River at the

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Commission's water filtration plant to the north shore of Watkins Island is conditioned in Section 181 of the aforesaid Water Resources Development Act of 1976 upon an enforceable Low Flow Allocation Agreement; and

WHEREAS, it is the judgment of the Chief of Engineers and the Secretary of the Army, acting pursuant to Section 10 of the Rivers and Harbors Act of 1899, that the public interest requires that such a Low Flow Allocation Agreement be a requirement for issuance of the permits for the construction of water intake structures in the subject portion of the Potomac River by the Commission and the Fairfax County Water Authority;

NOW, THEREFORE, in consideration of the premises and of the public and governmental interests deemed to be served hereby, the parties hereto do mutually agree as follows:

ARTICLE 1. Enforcement.

A. Certain Definitions:

1. Pertinent Portion of the River. The portion of the Potomac River subject to this Agreement is that located between Little Falls Dam and the farthest upstream limit of the pool of water behind the Chesapeake and Ohio Canal Company rubble dam at Seneca, Maryland. This portion is referred to herein as "the defined portion" or, alternately "the subject portion" of the Potomac River.

2. Parties. The Government, the State, the Commonwealth, and the District shall be termed "the governing parties." All other parties hereto shall be termed "member parties." The term "parties" shall mean all parties, both governing and member, except when the context otherwise requires.

B. Moderator. Authority to enforce the provisions of this Agreement shall be vested in an unbiased Moderator. It shall be the duty of the Moderator and he shall have the authority:

1. To take all actions necessary to enforce the provisions of this Agreement and his decisions hereunder, and for this purpose he may sue in his own name.

2. To decide all disputes between or among the parties arising under this Agreement not disposed of by consent.

The authority of the Moderator shall not restrict those powers reserved to the parties, including those specified in Article 3, Section C.

C. The decision of the Moderator shall be final and conclusive unless determined by a court of competent jurisdiction to have been fraudulent, capricious, arbitrary, or not supported by substantial evidence. All parties agree to accept and implement every decision of the Moderator unless and until said decision is overturned by a court competent jurisdiction.

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D. The parties specifically grant to the Moderator the authority to inspect documents, records, meters, facilities, and other items necessary to decide any question or verify reports made by any party as a consequence of this Agreement. Upon the request of any party, the Moderator shall provide said party any or all of the information held by him relevant to this Agreement.

E. Should the Moderator decide to commence or defend any action or otherwise have need of legal services relating to this Agreement, he shall have the right to contract with counsel for such purpose, and the cost of such services shall be repaid in equal shares by the governing parties. In the interest of prompt action, the Moderator may accept legal services, or an advance of funds, for such purpose from any party. Nothing herein shall require a party being sued by the Moderator to advance funds for such purpose.

F. The Moderator shall not be liable for injury or damage resulting from any decision or action taken in good faith without malice under apparent authority of this agreement, even though such decision or action is later judicially declared to be unauthorized or invalid.

G. The Moderator shall be selected, and may be relieved of his duties for any reason, by unanimous action of the governing parties expressed in a signed memorandum. Should the office of Moderator become vacant through death, resignation, or otherwise, a new Moderator shall be selected as soon as practicable by such unanimous action. During any period in which the office of Moderator remains vacant through a failure of unanimous action or otherwise, the full functions of the office of Moderator shall be exercised by a Standby Moderator who shall, except as expressly otherwise provided, be treated as the Moderator for all purposes under the provisions hereof. The duty to designate the Standby Moderator who shall, except as expressly otherwise provided, be treated as the Moderator for all purposes under the provisions hereof. The duty to designate the Standby Moderator shall rotate annually among the Government, the State, the Commonwealth, and the District in the order stated, beginning on the date this agreement becomes effective and rotating thereafter on the first day of each calendar year. Written notice of such annual designation shall be sent to all other parties by January 15 of each year. The first Moderator for this Agreement is designated in Annex A hereto.

H. Subject to the availability of funds, the reasonable expenses, including legal fees, and compensation of the Moderator shall be paid in equal shares by the governing parties. Any expense shall be deemed reasonable if at least three of the governing parties so agree or if so determined by a court. If any such party accepts as reasonable a particular expense not accepted as reasonable by the other such parties, that party may pay that expense, in addition to that party's proportionate share of all other expenses. At the time of each annual review as provided in Article 4 of this agreement, the governing parties shall set, by majority vote, the per diem fee to be paid a Moderator in the event his services shall be necessary. A Standby Moderator, who is an employee of

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the designating party or one of its political subdivisions or agencies, shall serve without fee in exercising the functions of the Moderator.

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I. The Moderator or any party may bring an action against any one or more other parties to enforce this Agreement or a decision of the Moderator made hereunder. Such action shall be brought in the United States District Court for the District of Columbia, and each party consents to venue in said court and to service of process upon it from said court, provided that if the action is between two states of the United States, such action may be commenced in the Supreme Court of the United States. In any such action the joinder of all parties hereto shall not be deemed necessary or indispensable merely because they are parties to this Agreement. Application for or receipt of a determination by the Moderator shall not be a prerequisite to the maintenance of an action by a party, but any decision made by the Moderator on a matter involved in said action, whether before or after commencement thereof, shall be given the effect set forth in Article I, Section C. Nothing herein shall be deemed to be a waiver of any immunity any party may have from a claim for monetary damages or a claim which has substantial fiscal impact, except for the fees and expenses which are provided to be paid pursuant to the agreement. It is the intention of the parties that any matters involving the technical aspects of maintenance of litigation be resolved in a manner which ensures rapid and certain enforcement of this Agreement.

ARTICLE 2. Administration.

A. Washington Aqueduct. The Government will provide a communication control center at the Washington Aqueduct for the administration of the allocation plan as provided herein. The Washington Aqueduct Division, U.S. Army Engineer District, Baltimore ("the Aqueduct"), will collect, receive, record and accumulate daily reports regarding the flow of the Potomac River and the quantities of water being withdrawn from the defined portion of the Potomac River, and the quantities of water withdrawn and available from all other sources for use within the Washington Metropolitan Area, by the parties and the political subdivisions, authorities, and permittees of any of them, and by any other water withdrawing entity which may formally be added or made subject to this Agreement subsequent to its initial execution. Subject to the parties' rights of appeal to the Moderator, the parties grant to the Aqueduct, and to each other, the right to inspect documents, records, meters, facilities and other items necessary to decide any question or verify reports made by any party as a consequence of this Agreement. Beginning with the Alert Stage, the Aqueduct will keep the Moderator informed as to the stage of flow in the Potomac River, and, during the Restriction and Emergency Stages the fair share allocated to each user, and all information utilized for determining the allocation. The Aqueduct will provide all parties with the same information relating to allocation, the quantities of water being withdrawn by all users from any and all sources, and the flow of the Potomac River. To permit uniformity of reports and to implement the administrative measures specified herein, reports and calculations, by or to the Aqueduct, of daily withdrawals or daily flows, will be based on the twenty-four hour period from one midnight to the following midnight, unless the parties subsequently agree to a

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different twenty-four hour measuring period. The Aqueduct will calculate the total daily flow by adding the withdrawals during the previous twenty-four hours at all withdrawal points and the remaining daily flow over the Washington Aqueduct Dam at Little Falls, as determined by the readings recorded on the USGS gauge at Little Falls during the preceding twenty-four (24) hours. The average reading will determine the flow over the dam for the previous day.

B. Stages of Flow in the Potomac River. The Aqueduct will determine from the information accumulated when the following stages exist in the defined portion of the Potomac River.

1. Alert Stage. When the total daily withdrawal from the subject portion of the Potomac River is equal to or greater than fifty percent (50%) of the total daily flow, but less than eighty percent (80%), the Aqueduct will declare an "Alert Stage" to be in effect.

2. Restriction Stage. When the total daily withdrawal from the subject portion of the Potomac River is equal to or greater than eighty percent (80%) of the total daily flow, the Aqueduct will declare a "Restriction Stage" to be in effect and the Aqueduct will request the U.S. Park Service to discontinue putting Potomac River water into the C&O Canal.

3. Emergency Stage. When the estimated total daily withdrawal for any day within the ensuing five (5) days from the subject portion of the Potomac River is expected to exceed the daily river flow anticipated, the Aqueduct will declare an "Emergency Stage" to be in effect.

C. Allocation of Flow. Whenever the Restriction Stage or the Emergency Stage is in effect, the Aqueduct shall daily calculate and advise each user (as defined herein), and the Moderator, of each user's allocated fair share of the water available from the subject portion of the Potomac River in accordance with this Section C. In calculating the amount of water available for allocation, the Aqueduct will determine, in consultation with the parties and based upon then current conditions and information, any amount needed for flow in the Potomac River downstream from the Little Falls dam for the purpose of maintaining environmental conditions ("environmental flow-by"), and shall balance such need against essential human, industrial and domestic requirements for water. The Aqueduct's determination shall be based upon the data and shall give substantial weight to conclusions for environmental flow-by submitted by the State.

1. For the purposes of this Section C, the term "users" refers to the following entities which are or may be appropriating water for public water supply purposes from the subject portion of the Potomac River; namely, the Government (including its water customers), the Commonwealth for and on behalf of herself and each of her political subdivisions and authorities (including the Authority), the State and the Administration (for and on behalf of its permittees whether or not parties to this Agreement), the District of Columbia, the Commission, and such entities which may formally be added or made subject to this Agreement subsequent to its initial execution.

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2. Each user shall report to the Aqueduct (and to each other) the number of gallons of processed water pumped daily to all its customers from all sources during each winter period (the months of December through February), commencing with the winter period 1977-78. The amounts pumped during the 5 most recent winter periods which have elapsed as of the time of allocation, or less than 5 if fewer have so elapsed, shall be combined for the purpose of computing each user's average daily winter use; except that, in the case of a user first withdrawing water subsequent to the initial execution of the Agreement, the average daily winter use of such user shall be the average of the amounts of water pumped during all of the winter periods, commencing December 1 of the year immediately prior to its first withdrawal from the subject portion of the river, which have elapsed as of the time of allocation, but not exceeding the 5 most recent winter periods. The ratio which the average daily winter use of each user bears to the average daily winter use of all users will be applied to the daily amount of water available at the time of allocation from the subject portion of the Potomac River (after deduction for environmental flow-by) and all other sources as specified in Paragraph 5 below (calculated at maximum capacity practicable). The resulting amount, less the amount then available to said user by use of the maximum capacity practicable from all such other sources, will be such user's allocated fair share of the flow of the Potomac River.

3. a. The formula set forth in Article 2.C.2. shall continue in effect unless changed by unanimous consent of the governing parties or as set forth below. After January 1, 1988, any of the governing parties which desires to change the allocation formula shall give written notice to all other parties. Within 60 days thereafter, both the governing and member parties shall meet for the purpose of negotiating a replacement formula. In the event that no such replacement formula is agreed on by the governing parties within one year after receipt of the aforesaid notice, the allocation ratio which would have been in effect for the summer of the year in which the notice was given shall be used as an interim allocation ratio for the withdrawal of water during subsequent periods of low flow until such time as the governing parties agree upon a replacement formula. Any governing party, at any time after the expiration of one year from the receipt of such notice and after the exhaustion of such administrative procedures as may be applicable if it is a permittee for water appropriation or withdrawal, may apply to a court of competent jurisdiction for an adjudication of such rights, if any, as it or users associated with it may have to a greater share of water than set by the interim allocation ratio, provided that all parties shall adhere to the interim allocation ratio until and unless altered by a decision of such court. Applications for intakes or other modifications to water works shall continue to be received and processed during periods in which the interim allocation ratio is in effect, but such ratio shall be recalculated only in the event of the grant of an application to a new user as set forth in Section E of Article 3.

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b. Any formula negotiated pursuant to subparagraph a. hereof shall allocate water on a fair and equitable basis and shall take into consideration, among other things, (a) steps taken by parties which can do so to minimize dependence upon the Potomac River during periods of low flow,

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(b) the nature and effectiveness of water conservation methods put into effect, (c) steps taken to increase the water supply available for the Washington Metropolitan Area, (d) then current population growth and planning for future growth, (e) feasibility and availability of new sources of water, and (f) technological advances in water treatment and water quality measurement.

c. In any court proceeding instituted pursuant to subparagraph a., neither the signing of this Agreement nor the passage of time thereafter shall be asserted as a waiver or diminution of any party's rights to, or right to seek, a greater share of water from the subject portion of the river. Such action shall be brought in the United States District Court for the District of Columbia, and each party consents to venue in such court and to service of process upon it from such court, provided that if the action is between two states of the United States, such action may be commenced in the Supreme Court of the United States.

4. In the event the applicable allocation formula results in an allocation exceeding the proposed withdrawal of any user, the excess amount shall be reported by said user to the Aqueduct for reallocation.

5. The water subject to the allocation formula under the terms of this Agreement includes the maximum capacity practicable from Patuxent and Occoquan as it exists in each case on December 31, 1977, and both the natural flow and the augmented flow from existing upstream reservoirs, in addition to Bloomington Lake, of the subject portion of the Potomac River. Any other augmentation to flow, reservoir storage, or treating capacity developed by a user after December 31, 1977, shall not be made subject to the allocation formula, but those users who incur, or participate in the payment of, the expenditures for such augmentation may agree as to how it is to be divided and shall file a copy of said agreement with the other parties. In recognition that the sole source of water supply for the District of Columbia is the Potomac River, each other party will offer the District an opportunity to participate in a portion of any additional augmentation for use during the Restriction and Emergency stages on reasonable terms, unless such party shows that it is infeasible to do so.

6. In the event a disaster, such as a major fire or water main break, results in an abnormal loss of a significant portion of any user's water supply, the Aqueduct shall determine suitable adjustments in low flow allocation during the emergency period created by the disaster only, taking into consideration all sources available to the users.

7. Water from the emergency pumping station having its intake at the estuary of the Potomac shall not be considered as water available from other sources for the purpose of Section 2.C.2 or otherwise included in computations made under this Agreement.

ARTICLE 3. Obligations of the Parties.

A. The Government agrees to cause the Aqueduct as the operating

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agency to perform the functions and requirements which are required of the Government and the Aqueduct in this Agreement, including the furnishing of information to the other parties relating to the Aqueduct's water withdrawal and use, the same as required by other parties to be furnished to the Aqueduct under Subparagraphs B and D, of this Article. These functions and responsibilities of the Aqueduct shall be carried out under the supervision of the District Engineer, U.S. Army Engineer District, Baltimore, or his designee, who shall be responsible for making the determinations required in the discharge of these responsibilities.

B. The parties agree to provide the Aqueduct with all the information relating to the withdrawal and use by them, their permittees, entities reporting through them and their political subdivisions, as applicable, of the waters of the subject portion of the Potomac River and availability from other sources which is needed for the administration of the allocation system.

C. The State agrees that all appropriation permits granted by the Administration for any appropriation of water from the subject portion of the Potomac River shall include a provision subjecting the permittee to the provisions of this Agreement. Nothing herein shall restrict or limit such authority as the Administration may properly have to issue permits or impose low flow allocation requirements upon any other water appropriating permittee withdrawing water from other segments of the Potomac River, or to enforce provisions of its permits in the subject portion of the Potomac River; nor any such authority as the Commonwealth may have; nor the authority of the Government with respect to navigable waters, including the regulation of commerce among the states and with foreign nations.

D. The parties will comply with the determinations made by the Aqueduct pursuant to this Agreement, unless and until overturned pursuant to the terms of Article 1.

E. Any community or entity which seeks to appropriate water from the subject portion of the Potomac River shall either become a member party to this Agreement or shall be governed by a permit which includes the low flow allocation formula and such other provisions as are necessary to effect the purposes of this Agreement. Any such community or entity may apply for permits necessary to build water intake structures or to appropriate water, and such permits shall be processed in accordance with the rules and regulations of the permit-issuing agency, notwithstanding the pendency of negotiations or the imposition of an interim allocation ratio pursuant to Section 2.C.3. If the necessary permits are granted to a community or entity not previously withdrawing water from the subject portion of the river, the existing interim allocation ratio shall be recalculated based on winter period use for the year immediately prior to the first withdrawal from the subject portion of the river by such new user. The average daily winter use of the new user for such winter period and those of the other users employed in determining the interim allocation ratio shall be employed to compute a revised interim allocation ratio which shall remain in effect until a replacement formula is determined pursuant to Section 2.C.3.

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F. This Agreement does not affect such rights as parties or others subject to this Agreement may have to grant or obtain permits to appropriate additional amounts of water during periods other than the Restriction or Emergency stages, but except as specifically provided in Article 2, Section C and Article 3, Section E, any additional water use resulting therefrom shall not affect any user's allocated fair share during such stages.

ARTICLE 4. Review.

In the month of April in each year during the term of this Agreement the parties shall convene for the purpose of reviewing the provisions of this Agreement and considering any modifications thereof, and make such modifications as the governing parties agree upon. Upon agreement among the governing parties, review and modifications as might be agreed upon can occur at any time and not be necessarily limited to the annual, April consideration. Entities shall be admitted as new member parties upon unanimous agreement of the governing parties.

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ARTICLE 5. Revocation.

This Agreement shall not be revoked without the unanimous consent of the governing parties.

ARTICLE 6. Effective Date.

This Agreement shall become binding when: (1) it is executed by the parties, and (2) a Moderator has been selected as provided in Article 1.G, and (3) the Government issues one or more permits for the construction of any water diversion structure or water intake in the subject portion of the Potomac River to any party hereto or political subdivision or authority thereof, and (4) all acts have been taken by each of the parties hereto necessary to make this agreement binding and enforceable with respect to each of them, including, if necessary, ratification by the legislatures of the signatory states. Notice that all such necessary acts have been taken by each of the parties shall be delivered to the other parties along with the opinion of its respective counsel or attorney general that the acts taken are sufficient to cause this agreement to become effective, binding and enforceable under the laws of charter of such parties. The parties will, however, commence to record and maintain the consumption figures and other base data called for under the foregoing provisions of this Agreement, at the time they execute this Agreement. This Agreement may be executed in one or more counterparts.

ARTICLE 7. Severability.

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The provisions of this Agreement shall be severable and if any phrase, clause, sentence or provision of the Agreement is declared to be

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unconstitutional or the applicability thereof to any party is held invalid, the remainder of such agreement shall not be affected thereby.

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IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written, except as a different date of execution may be noted following any party's signature.

(Original document signed by the following:)

ATTEST:

THE UNITED STATES OF AMERICA
BY

Secretary of the Army

Chief of Engineers

THE STATE OF MARYLAND
BY

Governor

Secretary of Natural
Resources

THE COMMONWEALTH OF VIRGINIA
BY

Governor

Vice Chairman, State Water
Control Board

THE DISTRICT OF COLUMBIA
BY

Mayor

Director of Environmental
Services

THE WASHINGTON SUBURBAN SANITARY
COMMISSION

BY

Chairman

FAIRFAX COUNTY WATER AUTHORITY
BY

Chairman

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APPENDIX B

POPULATION AND WATER DEMAND CALCULATIONS

The two determinants used to calculate water demand for the Washington Metropolitan Area (WMA) were population and employment. Population was used as the basis for residential water demand in the WMA and employment data provided the estimates of commercial and industrial water uses.

RESIDENTIAL POPULATION

Population data were provided by the U.S. Army Corps of Engineers (C.O.E.) and the Metropolitan Washington Council of Governments (MWCOC). The C.O.E.'s estimates were made by political subdivision for 1970 and from 1980 to 2030 in five year increments. The MWCOC's were made at the traffic zone level for 1970, 1980, 1985, 1990, and 1995.

Regression equations (Table B-1) were developed based on C.O.E. data to project the population to the year 2050 for those utilities whose service area corresponds to the political boundaries. Those utilities include Washington Aqueduct, Arlington, Fairfax City, and Alexandria.

TABLE B-1

WAD	Y =	571.43 + 400.00 X
Arlington	Y =	550,251.02 + -178.57 X
Fairfax City	Y = -	134,178.57 + 78.75 X
Alexandria	Y = -1,960,963.27	+1,064.29 X

Y = population

X = year of projection (e.g. 2050)

The equations were based on C.O.E. estimates from the years 2000 to 2030.

In Falls Church, Virginia, the service area corresponds to a specific set of traffic zones. The population for 1975 was estimated using the average population for 1970 and 1980 from the MWCOC data. A regression equation was developed from the 1970 - 1995 data to project population growth to the year 2050 at five year increments.

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$$\text{Falls Church } Y = -4,094,800 + 2,140 X$$

Y = population
X = year of projection (e.g. 2000)

The other small water utilities did not have service area boundaries that corresponded with either political or traffic zone boundaries. In those traffic zones split by a utility, street maps were used to identify the populated areas. Next, the percentage of a traffic zone's population in each service area was calculated using MWCOG data. When the population served by each utility was determined for 1970, the same techniques used for the Falls Church service area were utilized to predict population through the year 2050 at five year increments. The regression equations for those utilities follow:

TABLE B-2.

Fort Belvoir	Y = - 108,070 + 62.00 X
Reformatory	Y = - 84,247.6 + 44.36 X
Herndon	Y = - 1,983.434 + 1,010.4 X
Clifton	Y = - 44,207.5 + 22.58 X
Occoquan	Y = -2,183,305.2 + 1,125.48 X
Dumfries	Y = - 558,544.5 + 287.34 X
Virginia American	Y = - 647,850 + 340.00 X
Manassas	Y = - 763,232.7 + 391.98 X
Rockville	Y = - 68,718.3 + 56.02 X
Leesburg	Y = - 356,570.0 + 184.00 X

Y = population
X = year of prediction (e.g. 2030)

Although the C.O.E. made population projections for WSSC and FCWA, those service populations had to be adjusted downward to account for the independent utilities listed above by subtracting those populations. Regression equations were derived from the 1975 - 1995 data to project populations to the year 2050 as in the previous two examples. The equations follow:

WSSC	Y = -53,374,373.78 + 27,623.976 X
Remainder of Fairfax Co.	Y = -31,352,968.84 + 16,080.664 X

Table B-3 lists the residential population estimates for the service areas and utilities.

EMPLOYMENT FORECASTS

Employment estimates in the service areas of water utilities in greater Washington, D.C. are based on the Metropolitan Washington Council of Governments' 1974 Regional Employment Census and the MWCOG's employment forecasts for the period 1972 to 1995.

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TABLE B-3. HISTORICAL POPULATION ESTIMATES FOR SERVICE AREAS AND UTILITIES

	U.S.D.	ALEXANDRIA	ABU-LUJAIN	FAIRFAX	FAIRFAX CITY	FAIRFAX COUNTY	ROCKVILLE	HAMASAS	VIRGINIA AMERICAN	EMPRES	OCCOCHAN	HERNDON	CLEFTON	ROCKVILLE	FAIRFAX COUNTY	WOLFE SPRING
1975	755,000	115,000	161,000	22,000	129,000	14,300	3,325	10,320	400	37,788	8,488	20,930	10,588	40,002	406,623	1,215,116
1980	780,000	127,000	168,000	22,000	142,000	14,300	3,325	12,320	517	46,300	10,865	27,300	13,475	42,071	485,700	1,285,128
1985	795,000	137,000	175,000	22,000	157,000	14,300	3,325	13,840	606	52,400	12,180	29,300	14,930	47,408	505,700	1,345,932
1990	795,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
1995	795,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2000	795,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2005	805,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2010	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2015	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2020	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2025	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2030	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2035	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2040	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2045	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264
2050	810,000	140,000	181,000	22,000	160,000	15,200	4,241	15,160	900	56,600	13,000	30,000	15,075	51,350	520,066	1,406,264

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Traffic zones in the Metropolitan area were matched against the utilities' service areas. For those traffic zones contained in more than one service area, the percentage of the total employment in each utility area was estimated for 1972 using maps. These same percentages were used to allocate employment for the years of 1980, 1985, 1990, and 1995. Once the employment in the traffic zones was allocated to the service areas, total employment in each utility service area was calculated. The employment for each utility was estimated in five year increments for the years 2000 to 2050, based on regression equations derived from the 1975 to 1995 estimates. Regression equations for the individual utilities are shown in Table B-4.

The MWCOG's 1974 Regional employment summary was used to estimate employment in different categories, such as government, manufacturing, and trade. Once all the employment categories were summed for each service area, the percentage of the total breakdown was used to estimate employment in each category for all the years concerned. Employment estimates for the individual utilities are listed in Table B-5.

DEMAND SCENARIOS 6-1/2"

The population and employment estimates derived from each water utility were used to estimate water consumption under different demand scenarios. For each utility and each forecasted year, population and employment figures were multiplied by appropriate use rates. In this way, it was possible to estimate the total demand for water in Metropolitan Washington at different times in the future.

Two sets of annual use rates were estimated, one for residential and the second for other consumption (employment). Three different spatial areas were utilized for demand calculation: Washington Suburban Sanitary Commission, the Washington Aqueduct Service Area, and the Virginia utilities. Table B-6 contains residential and employment demands in mil gal per capita per year.

TABLE B-6. DEMAND RATE FOR SERVICE AREAS

Area	Residential Rate (mil gal/capita/yr)	Non-Residential Rate (mil gal/employee/yr)
Washington Aqueduct	0.01789	0.05217
WSSC	0.02611	0.02229
FCWA	0.03489	0.01870

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TABLE B-4. REGRESSION FOR ESTIMATING EMPLOYMENT LEVELS

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WAD	Y =	623,340.00 + 35,460.00 X
WSSC	Y =	337,800.00 + 82,858.70 X
Rockville	Y =	17,458.90 + 3,111.00 X
Arlington	Y =	126,860.00 + 12,855.00 X
Falls Church	Y =	50,250.40 + 9,832.40 X
Fairfax City	Y =	16,530.00 + 2,180.00 X
Herndon	Y =	1,090.70 + 1,031.70 X
Clifton	Y =	28.00 + 14.00 X
Alexandria	Y =	45,420.20 + 7,432.40 X
Fort Belvoir	Y =	19,180.00 + 1,000.00 X
Dulles Airport	Y =	2,394.90 + 498.80 X
Greater Manassas	Y =	3,414.90 + 250.50 X
Virginia American	Y =	510.40 + 1,262.40 X
Occoquan	Y =	4,765.20 + 1,926.20 X
Dumfries	Y =	995.10 + 1,108.10 X
Reformatory	Y =	1,060.00 + 210.00 X
Remainder of		
Fairfax County	Y =	60,722.50 + 29,380.50 X
Leesburg	Y =	2,620.40 + 82.40 X

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TABLE B-5. EMPLOYMENT ESTIMATES FOR SERVICE AREAS AND UTILITIES.

	MSJC	ROCKVILLE	MAD	ARLINGTON	FALLS	CHURCH	CITY	HERNDON	CLIFTON	ALEXANDRIA	FORT	BLVD	AIRPORT	GREATER	VIRGINIA	OCCUPATION	EMPLOYEES	REFORM-	REMAINING	LEASING
1975	618,666	20,585	659,600	144,425	62,530	18,350	2,039	0	52,288	20,200	2,973	3,711	1,708	6,719	2,147	1,250	91,800	2,738		
1980	696,751	23,749	702,100	151,300	68,600	21,600	3,255	0	61,100	21,200	3,430	3,954	3,100	8,750	3,225	1,500	119,055	2,800		
1985	575,203	26,797	738,800	158,800	77,600	23,000	4,100	0	67,400	22,300	3,820	4,071	4,200	10,450	4,275	1,700	146,100	2,800		
1990	667,858	28,642	760,100	176,500	88,000	24,700	5,450	0	76,100	22,800	4,305	4,311	5,900	12,150	5,300	1,900	172,550	2,900		
1995	760,405	33,185	797,900	196,100	102,000	27,700	6,095	70	83,200	24,400	4,980	4,785	6,900	14,850	6,450	2,100	209,635	3,100		
2000	815,952	36,128	816,100	203,990	109,245	29,610	7,281	56	90,015	25,180	5,388	4,920	8,085	16,322	7,444	2,320	237,006	3,115		
2005	917,811	39,239	871,560	216,865	119,077	31,790	8,313	70	97,647	26,180	5,887	5,168	9,347	18,249	8,752	2,530	266,366	3,197		
2010	1,090,669	42,151	907,020	229,700	128,910	33,970	9,364	84	106,800	27,180	6,386	5,419	10,610	20,175	9,860	2,740	295,767	3,278		
2015	1,083,228	45,462	947,680	242,555	136,742	36,150	10,376	98	112,312	28,180	6,885	5,669	11,872	22,101	10,968	2,950	325,147	3,362		
2020	1,116,386	48,576	977,910	255,410	148,574	38,330	11,408	112	119,744	29,180	7,384	5,920	13,134	24,027	12,076	3,160	354,528	3,444		
2025	1,249,265	51,685	1,013,400	268,265	158,407	40,510	12,439	126	127,177	30,180	7,883	6,170	14,397	25,953	13,184	3,370	381,808	3,527		
2030	1,372,103	54,797	1,048,860	281,120	168,239	42,690	13,471	140	136,609	31,180	8,382	6,421	15,659	27,880	14,292	3,580	413,289	3,609		
2035	1,415,963	57,908	1,084,370	293,975	178,072	44,870	14,503	210	142,052	32,180	8,881	6,671	16,922	29,806	15,400	3,790	442,669	3,692		
2040	1,497,822	61,020	1,119,780	306,830	187,904	47,050	15,554	224	148,476	33,180	9,380	6,922	18,184	31,732	16,508	4,000	472,050	3,774		
2045	1,580,680	64,131	1,155,240	319,685	197,736	49,230	16,566	238	156,806	34,180	9,878	7,172	19,446	33,658	17,617	4,210	501,430	3,856		
2050	1,663,539	67,243	1,190,700	332,540	207,569	51,410	17,598	252	164,339	35,180	10,377	7,423	20,709	35,584	18,725	4,420	530,810	3,939		

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To show the effect that different per capita rates of consumption will have on total demand in the WMA, various assumptions were made concerning variations in consumption. These variations are shown in Table B-7. Results of these evaluations in total water demand are shown in Figure B-1.

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TABLE B-7. PER CAPITA WATER USAGE SCENARIO

Scenario	Description of per capita change over 10-year period
1	Growth in per capita and per employee water usage over entire WMA of 10%.
2	Growth in per capita and per employee water usage over entire WMA outside of District of Columbia (DC) of 10% but a decrease of 5% per capita and per employee use in D.C.
3	Maximum growth in per capita and per employee water usage over entire WMA of 5%.
4	No growth in per capita and per employee water usage over entire WMA. Current use assumed constant.
5	Decrease of 5% per capita and per employee use in D.C., and constant (no increase) use elsewhere in D.C. area.
6	Decrease of 5% per capita and per employee use over entire WMA.

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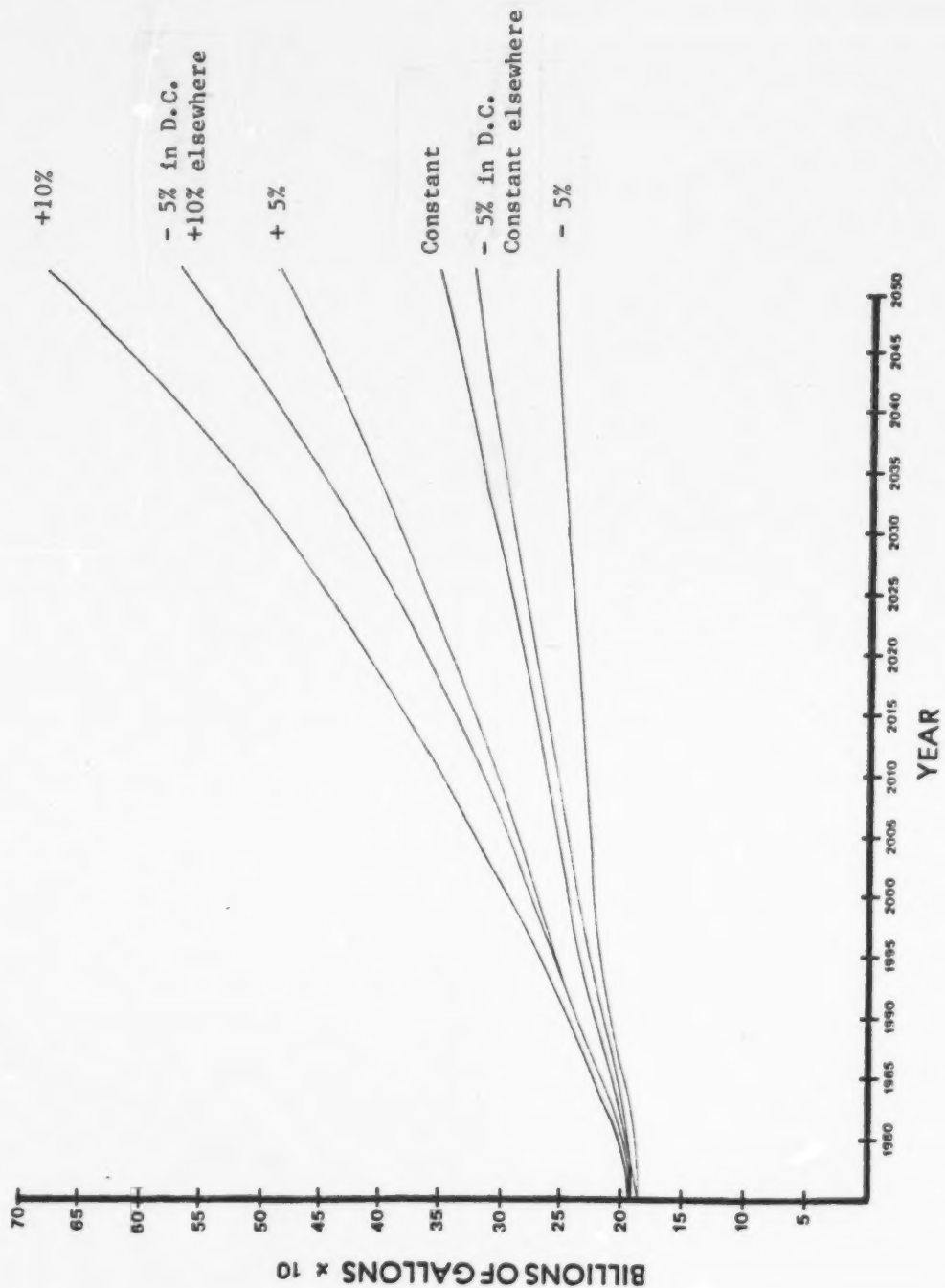


Figure B-1. Future water use (% changes are over 10 year periods) under different water demands.

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APPENDIX C

ANALYSIS OF FLOWS IN THE POTOMAC RIVER

To more accurately assess flows available in the Potomac River for water supply, a deficit analysis approach was used. A deficit analysis matches available flow versus actual or projected demand. If demand exceeds available flow a deficit occurs which must be satisfied by some flow augmentation procedure. The deficit approach is probably best illustrated by Figure C-1 in which the 1966 river flow is balanced against two projected monthly water demands for the WMA. The jagged line is the flow of record and the horizontal lines are monthly demands for the years 1980, 2030, and 2050. As can be seen the shaded area is the anticipated deficit. For the 2050 demand the anticipated deficit is large and lasts over a 2-1/2 month period. For the 1980 demand the deficit is small and occurs twice for short periods of time within the low flow period. It is interesting to note that tiny deficits occur in January for the 2050 demand and the available flow and the demands are close from October through December.

A computer program was developed to perform a deficit analysis for the WMA. The program called the Deficit Flow Program compares past stream flow data with future demand projections, and has been employed to help estimate the capacity of the Potomac River to meet the demand for water in Metropolitan Washington between 1980 and 2050.

The program utilizes stream flow from the following rivers: Potomac at Point of Rocks, Maryland; Seneca Creek at Dawsonville, Maryland; Difficult Run near Great Falls, Virginia; Goose Creek near Leesburg, Virginia and the Monocacy in Maryland. Most water available for use in the WMA is in the Potomac and as such passes the river gauge at Point of Rocks, Maryland. Therefore Point of Rocks was used as the primary gauge for measuring available water. Daily flows were examined for the years 1909 through 1975. Daily flows were entered for the entire year.

The flows for the other four streams considered were estimated from data available at the gauge nearest to the streams' confluence with the Potomac. The flows in the months July through December for the years 1930, 1932, 1944, 1948, 1964, 1965, and 1966 were examined for each gauge. These were the low flow years of record for the Point of Rocks gauge. The date of low flow for the Point of Rocks gauge was established for the months July through December for the given years. The corresponding flow was determined for each of the other four gauges. Each of the flows for the non-Potomac gauges was multiplied by a drainage factor to yield an estimate of the flow at the stream confluence with the Potomac. These drainage factors are shown in Table C-1.

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Figure C-1. Deficit flow conditions for 1980, 2030, and 2050 demand vs 1966 flow.

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TABLE C-1. DRAINAGE FACTORS FOR NON-POTOMAC STREAMS

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Monocacy	1.187
Goose Creek	1.160
Seneca Creek	1.277
Difficult Run	1.000

Adjusted flows for the four non-Potomac streams were summed with the Point of Rocks low flow to yield an estimate of flow just above the WMA intakes. Table C-2 shows an example calculation. For July 19, 1942, the low flow at Point of Rocks, the following adjustment was made to the stream flow registered at each non-Potomac stream.

TABLE C-2. EXAMPLES OF ADJUSTMENT TO STREAM FLOW

	<u>Drainage Factor</u>	<u>Low Flow</u>
Monocacy	(1.187)	(227) = 269.45 cu ft
Goose Creek	(1.160)	(33) = 38.28 cu ft
Seneca Creek	(1.277)	(13) = 34.48 cu ft
Difficult Run	(1.000)	(13) = <u>13.00 cu ft</u>
Adjusted Total		355.21 cu ft

This total is added to the Point of Rocks as follows:

Point of Rocks (low flow)	2,060.00 cu ft
Additional streams	<u>355.21 cu ft</u>
Estimated total at Washington, D.C.	2,415.21 cu ft

A regression equation was developed to convert Point of Rocks flow into total flow available above the WMA intake taking into account the contribution of the four tributaries. In this regression, Potomac flow was the independent variable and total flow was the dependent variable. The resulting equation that converts flow in cubic feet per second at the Point of Rocks gauge to mil gallons per day above the WMA intakes is as follows:

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$$Y = 0.646 (0.7976 Q^{1.052}) (r^2 = 0.99) \quad (c-1)$$

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where

Q = cubic ft per second at Point of Rocks and

Y = mil gal per day above WMA intakes

These flows estimated by equation C-1 were balanced against estimated demands to determine the frequency and magnitude of deficits in the Potomac.

DEMAND ESTIMATES

Using population forecasts as developed in Appendix B, six annual demand scenarios were developed based on population estimates. Once the basic annual rate of demand was determined for a given scenario, the annual demand was modified by a factor which reflected the ratio of monthly demand to average monthly demand. Average monthly demand is shown in Table C-3. The factor used to convert average monthly demand to individual monthly demand is given in Table C-4.

Table C-5 contains the monthly demands for June through December for two different demand scenarios (current per capita use rates and 5 percent conservation per decade). Each of the demand figures as calculated from the factors in Tables C-4 and C-5 have been augmented by a 100-MGD flow-by requirement for the Potomac estuary.

TABLE C-3. AVERAGE MONTHLY WMA WATER DEMAND IN MGD

1980	471.7
1985	519.8
1990	566.3
1995	611.2
2000	646.8
2005	682.4
2010	717.6
2015	754.2
2020	783.7
2025	825.1
2030	858.7

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TABLE C-4. MONTHLY DEMAND DISTRIBUTION FACTORS

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<u>Month</u>	<u>Distribution Factor</u>
June	1.10197
July	1.19137
August	1.15593
September	1.10393
October	0.99877
November	0.94830
December	0.91897

The Patuxent, Occoquan, and other WMA water supplies, provide 121 MGD to the WMA. Therefore, 121 MGD was subtracted from Table C-5 to yield the values shown in Table C-6, or the actual flow required in the Potomac to satisfy both water supply and ecological demands.

DEFICIT ANALYSIS PROGRAM

A computer program was developed to use both supply and demand data to produce deficit analysis. Deficits were calculated by comparing the estimated future demand with past flow records. An average daily demand for each month as shown in Table C-6 was subtracted from each day's flow for every year from 1909 to 1975 giving both size and frequency of future deficits. For each of the years the dates of deficits based on historical stream flows were listed. The date of the first day of a deficit and the last day of a deficit were recorded. A deficit period is defined as a continuous period of days with deficits. For each deficit period, the total deficit in cubic feet was totaled. All the deficit periods in a year were identified by their beginning and ending dates and the total annual deficit was summed from all the individual deficits. Two reports were generated; one report listed future deficits based on flows in past years and the second created histograms that provided a revised display of their deficit data.

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The effect of peak demands on water availability was also examined to assess the worst possible conditions that the WMA might experience. The average month's water demand was multiplied by factors (Table C-7) that

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TABLE C-5. DEMAND ESTIMATES BY MONTH FOR METROPOLITAN WASHINGTON, D.C.

IN MGD (with 100 mgd flowby requirement)

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Year		June	July	Aug	Sep	Oct	Nov	Dec
1980	Constant per capita rate	620	662	645	621	571	547	533
1985	Constant per capita rate	673	719	701	647	619	593	577
	5% per decade reduction	656	702	684	657	604	579	563
1990	Constant per capita rate	724	775	755	725	666	637	620
	5% per decade reduction	693	741	722	694	637	610	594
1995	Constant per capita rate	774	828	807	775	710	680	661
	5% per decade reduction	717	767	747	718	659	631	614
2000	Constant per capita rate	813	871	848	814	746	713	694
	5% per decade reduction	741	793	773	743	681	652	634
2005	Constant per capita rate	852	913	889	853	782	747	726
	5% per decade reduction	757	810	789	758	695	665	647
2010	Constant per capita rate	891	955	929	892	817	781	759
	5% per decade reduction	772	827	805	773	709	678	660
2015	Constant per capita rate	931	999	972	933	853	815	792
	5% per decade reduction	782	837	815	783	718	687	668
2020	Constant per capita rate	964	1034	1006	965	883	843	819
	5% per decade reduction	791	847	825	796	726	695	676
2025	Constant per capita rate	1009	1083	1054	1011	924	882	857
	5% per decade reduction	800	857	835	802	735	703	683
2030	Constant per capita rate	1046	1123	1093	1048	958	914	888
	5% per decade reduction	810	867	844	811	743	711	691

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TABLE C-6. DEMAND ESTIMATES BY MONTH FOR METROPOLITAN WASHINGTON, D.C.

IN MGD EXCLUDING WATER PROVIDED BY THE PATUXENT AND OCCOQUAN

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Year		June	July	Aug	Sep	Oct	Nov	Dec
1980	Constant per capita rate	499	541	524	500	450	426	412
1985	Constant per capita rate	552	598	580	553	498	472	456
	5% per decade reduction	535	581	563	536	483	458	442
1990	Constant per capita rate	603	654	634	604	545	516	499
	5% per decade reduction	572	620	601	573	516	489	473
1995	Constant per capita rate	653	707	686	654	589	559	540
	5% per decade reduction	596	646	626	597	538	510	493
2000	Constant per capita rate	692	750	727	693	625	592	573
	5% per decade reduction	620	672	652	622	560	531	513
2005	Constant per capita rate	731	792	768	732	661	625	605
	5% per decade reduction	636	689	668	637	574	544	526
2010	Constant per capita rate	770	834	808	771	696	660	638
	5% per decade reduction	651	706	684	652	588	557	539
2015	Constant per capita rate	810	878	851	812	732	694	671
	5% per decade reduction	661	716	694	662	597	566	547
2020	Constant per capita rate	843	913	885	844	762	722	698
	5% per decade reduction	670	726	704	671	605	574	555
2025	Constant per capita rate	888	962	933	890	803	761	736
	5% per decade reduction	679	736	714	681	614	582	562
2030	Constant per capita rate	925	1002	972	927	837	793	767
	5% per decade reduction	689	746	723	690	622	590	570

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translated the average months demand in Table C-5 into a maximum one day demand. These peak demands appear in Table C-8 augmented by a 100-MGD flow by requirement. In Table C-9 the demand is reduced by the available supply of 121 MGD available from the Patuxent and Occoquan.

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TABLE C-7. PEAK DAY DEMAND FACTORS

<u>Month</u>	<u>Distribution Factor</u>
June	1.2789
July	1.40582
August	1.47959
September	1.28056
October	1.07867
November	1.01468
December	1.01468

For each deficit period the peak deficit is identified as the day that experiences the greatest deficit in the entire deficit period. The lowest daily flow is subtracted from the peak day to provide an estimate of possible short-term deficits.

Table C-10 provides some examples of the deficit calculations.

DEFICIT FLOW PROGRAM

The deficit analysis program is written in FORTRAN and is operational on the Univac 1110 at the EPA facility in Research Triangle Park. Various numbers used to determine water usage and deficit calculations are stored in data statements which are included at compile time. This allows the program size to remain relatively small, but still be flexible enough to handle various scenarios hypothesized.

Data are read in, using Univac informatted I/10. First, the date is read and the counter for the data is determined by the number of days in the month. After the data are read in, these are converted into cubic feet and subtracted from the usage numbers for the appropriate month and year. After all the data have been properly converted, they are then checked for deficit and surplus periods. The beginning and ending dates of both the deficit and surplus periods are listed as well as the total value of these periods. Also, for the deficit periods, the maximum one day deficit date

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TABLE C-8. PEAK DEMAND ESTIMATES BY MONTH FOR METROPOLITAN WASHINGTON, D.C.

IN MGD (with 100 mgd flow by requirement)

Year		June	July	Aug	Sep	Oct	Nov	Dec
1980	Constant per capita rate	703	763	798	704	609	579	563
1985	Constant per capita rate	764	831	869	766	661	627	611
	5% per decade reduction	745	810	847	747	645	612	596
1990	Constant per capita rate	825	896	938	825	711	675	656
	5% per decade reduction	788	856	896	789	680	646	628
1995	Constant per capita rate	881	959	1004	883	759	720	700
	5% per decade reduction	816	887	929	817	704	668	650
2000	Constant per capita rate	927	1009	1057	928	798	756	735
	5% per decade reduction	844	918	961	845	728	691	672
2005	Constant per capita rate	972	1059	1110	974	836	792	770
	5% per decade reduction	862	938	982	863	743	705	686
2010	Constant per capita rate	1017	1109	1162	1019	874	828	805
	5% per decade reduction	880	958	1003	881	758	719	699
2015	Constant per capita rate	1064	1160	1216	1066	914	865	841
	5% per decade reduction	891	969	1015	892	767	728	708
2020	Constant per capita rate	1102	1202	1260	1104	945	895	870
	5% per decade reduction	901	981	1028	903	776	736	716
2025	Constant per capita rate	1155	1260	1321	1157	990	937	910
	5% per decade reduction	912	993	1040	914	785	745	724
2030	Constant per capita rate	1198	1307	1371	1200	1026	971	943
	5% per decade reduction	923	1005	1053	925	795	753	733

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TABLE C-9. PEAK DEMAND ESTIMATES BY MONTH FOR METROPOLITAN WASHINGTON, D.C.
IN MGD WITH WATER FROM OTHER STREAMS INCLUDED

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Year		June	July	Aug	Sep	Oct	Nov	Dec
1980	Constant per capita rate	582	642	677	583	488	458	442
1985	Constant per capita rate	643	710	748	645	540	506	490
	5% per decade reduction	624	689	726	626	524	491	475
1990	Constant per capita rate	703	775	817	704	590	554	535
	5% per decade reduction	677	735	775	668	559	525	507
1995	Constant per capita rate	760	838	883	762	638	599	579
	5% per decade reduction	695	766	808	696	583	547	529
2000	Constant per capita rate	806	888	936	807	677	635	614
	5% per decade reduction	723	797	840	724	607	570	551
2005	Constant per capita rate	851	938	989	853	715	671	649
	5% per decade reduction	741	817	861	742	622	584	565
2010	Constant per capita rate	896	988	1041	898	753	707	684
	5% per decade reduction	759	837	882	760	637	598	578
2015	Constant per capita rate	943	1039	1095	945	793	744	720
	5% per decade reduction	770	848	894	771	646	607	587
2020	Constant per capita rate	981	1081	1139	983	824	774	749
	5% per decade reduction	780	860	907	782	655	615	595
2025	Constant per capita rate	1034	1139	1200	1036	869	816	789
	5% per decade reduction	791	872	919	793	664	624	603
2030	Constant per capita rate	1077	1186	1250	1079	905	850	822
	5% per decade reduction	802	884	932	804	674	632	612

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TABLE C-10. EXAMPLE OF DEFICIT CALCULATION

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The following calculations are for a deficit projected on October 14th and 15th, based on 1963 stream flow data. The scenario used is the Potomac River without conservation.

The monthly requirement for October 1985 is 619 MGD.

The flow on October 14th and 15th, 1963 was 840 cu ft/sec and 820 cu ft/sec respectively.

The adjusted flow is calculated for each day, as follows:

$$\text{Oct 14} = (0.7976 [840]^{1.052})^{0.646} = 614.27 \text{ MG}$$

$$\text{Oct 15} = (0.7976 [820]^{1.052})^{0.646} = 598.89 \text{ MG}$$

The individual deficits (MG) are:

$$\text{Oct 14} = 614.27 \text{ (available)} - 619 \text{ (demand)} = -4.73$$

$$\text{Oct 15} = 598.89 \text{ (available)} - 619 \text{ (demand)} = \underline{-20.11}$$

Total deficit for deficit period 24.84 MG

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and amount are listed. When all deficit and surplus periods have been identified, the yearly totals for each are listed and statistics are calculated for the deficits.

The program uses the totals calculated in the above procedure to generate histograms based on Biomedical Computer Programs, P-series (PMDP) PSD. The program writes the Univac and BMDP control cards onto a disk file, unit 8 in the program. After the main program terminates, the user enters the command at ADD BMDPFILE.; this submits the card images for execution. Flow diagrams are shown in Figure C-2.

A complete listing of the Univac commands needed to execute this program follows.

Univac Commands

Sign on to RTP with a valid account number and userid. Then enter the following commands:

1. @ ASC, CP PRING., F40/1/POS/3
2. @ COPY, A MS100*FLOWP., TPF\$
3. @ ASG, A MR100* POTOMAC.
4. @ USE 3., MR100* POTOMAC.
5. @ ASG, A MR*BMDPFILE.
6. @ USE 8., MR100*BMDPFILE.
7. @ BRKPT PRIN\$/PRINT
8. @ HDG X.M, 64,0,4
9. @ XQT TPF\$.PGMX
10. @ ADD MR100* BMDPFILE.
11. @ BKRPT PRINT\$
12. @ FREE PRINT.
13. @ SYM PRINT.,,SITEID

Explanation:

1. This assigns an alternate print file onto which the reports and histograms will be written.
2. Copy the absolute, or executable, elements of file MR100*FLOWP. to the users own temporary file.

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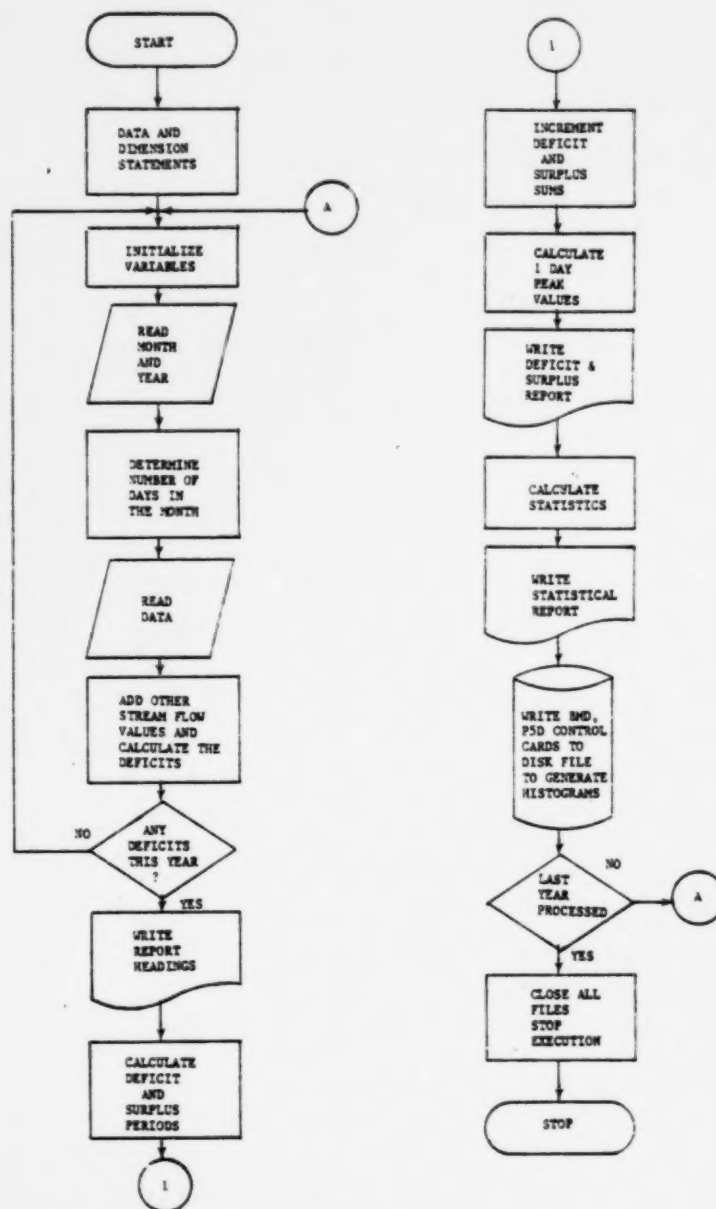


Figure C-2. Potomac Flow Analysis Program system flowchart.

3. Assign the data file to the run.
4. Assign the unit number 3 to the data file.
5. Assign the file for the BMDP command statements to the run.
6. Assign the unit number 8 to the BMDP file.
7. Breakpoint the system print file to the alternate print file.
8. Establish the page spacing for the printed page, i.e., 64 lines per page, 4 blank lines at the bottom of the page.
9. Execute the program, PGMX where X is either a 1, 2, 3 or 4, depending on which scenario is to be used, defined as follows:
 - PGM 1 - with conservation, no WMA water added.
 - PGM 2 - without conservation, no WMA water added.
 - PGM 3 - without conservation, other WMA water added.
 - PGM 4 - with conservation, other WMA water added.
10. Add the BMDP control cards into the run stream. This produces histograms.
11. Close the alternate print file.
12. Free the alternate print file. This also catalogues the file.
13. Send the alternate print file to the user's SITEID.

RECONCILIATION OF C.O.E. AND EPA WATER DEMAND ESTIMATES

Because of recent (August 1979) demand estimates calculated by the C.O.E., an effort was made to check data in this report with the new C.O.E. estimates. To illustrate the average MWA water demand, the 1980 estimate was compared to the C.O.E. data for WAD, WSSC, Fairfax County, and Rockville. The EPA estimated demand (Table C-3) is 471.7 MGD. The C.O.E. estimate was 416.93 MGD. Included is an 11 percent increase to the C.O.E. figure which is the amount of water assumed conserved in their scenario #3, resulting in a total of 462.62 MGD. The figures for 2030 are as follows:

EPA	858.7 MGD
C.O.E.	691.0 MGD
C.O.E. + 11%	767.0 MGD

The EPA value is about 10 percent higher than the adjusted C.O.E. value. EPA's population, employment, and water demand projections were broken down into individual cities such as Clifton, Manassas, Herndon, etc., and this could account for some of the differences.

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APPENDIX D

FACILITY SELECTION PROGRAM

A facility selection program was used to find the costs associated with the reservoir interconnection and RWW alternatives. The program was developed from a methodology originally described in Renovated Wastewater as a Supplementary Source for Municipal Water Supply: An Economic Analysis. This methodology deals with a facility selection process for incrementally increasing the available water supply of a utility, when due to growth in demand, existing water resources become inadequate. It is assumed that the original, non-supplemented water supply sources of these utilities are dependable, and that the demand for new water will be uniform over the projected period of interest.

These assumptions, obviously, represent only a limited variety of the types of water shortage problems faced by affected areas. This version of the program does have the capability to investigate the effects which short term deficit conditions have on a utility. Under deficit conditions, the demand for water will probably exceed the available supply for only a few months out of each year. For the rest of the time, the original available supply of water will more than meet the demands of the area. Deficit conditions necessitate that demand be dealt with on a daily or weekly basis, and that additional water sources be brought on line based on maximum daily or weekly demands. But this method of utilizing additional water sources will produce a large excess capacity in the water supply system over a long period of time. A fixed O&M cost has, therefore, been incorporated to account for plant O&M costs at low or zero plant utilization rates.

In the following sections of this discussion the methodology used to construct this program will be presented. A case study describing an application of this program will also be presented.

PROGRAM DESCRIPTION

The Facilities Selection Program addresses the following resource planning problems. Forecasts of drinking water demands have been calculated for a particular area over a desired time period. Water supply schemes are developed to offset either permanent or short-term water deficits. An implementation schedule for the components of each scheme needs to be developed so that all predicted water deficits will be met at a minimum cost. Decisions must be made as to what is the optimal schedule for facility implementation, what amount of water is required from each facility, and how costs are to be assessed to individual facilities.

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Decisions must also be made, concerning the time-phased construction of a transmission line network, to ensure sufficient transmission capacity.

The program can be used to develop an implementation schedule for water supply facilities. A series of constraints are tested for every year within the period of time defined by the supply and demand schedule to determine when additional water supplies are required. New water sources are added to the supply system when the augmented available supply just falls below water demand. Figure D-1 displays a listing of the program segment containing this pseudo-optimization procedure. If a renovated wastewater treatment plant is brought on line when there is no additional water available for renovation (the total amount of demand water that can be recycled is already allocated), an error message will result and program execution will cease. Implementation schedules for water supply sources may be entered as data to investigate the impact of suboptimal schedules, or for meeting demands on an average daily, weekly, or monthly basis.

Capacity utilization for each facility is based upon both the type of source and the option under which the program is running. Renovated waste water (RWW) plants always operate at a combined and equivalent percent utilization rate. That is, as each RWW plant is entered into the solution, the capacity which it can provide is added to the combined capacities of the other RWW plants already on line. The amount of deficit water allocated for makeup by the RWW system is then shared on an equi-percent basis. Non-RWW sources are operated in a manner established by the program option in use. When the options which call the built-in optimization procedure are used, each non-RWW source will be utilized at an increasing rate until full capacity is reached. The facility will continue to operate at peak capacity through the end of the case study period (unless the demand should fall off). If the optimization procedure is not used, each plant, as it is brought on line, will immediately contribute 100 percent of its capacity. One final distinction has to be made between the operating procedures of RWW plants and non-RWW plants when they appear simultaneously in a solution. Since all RWW plants operate as a system, the non-RWW facilities will always be fully utilized and any deficit remaining will be made up by the RWW system.

A transmission line implementation schedule can be developed by the program from the water supply source implementation schedule. The transmission capacity associated with a water source is increased to a level just greater than or equal to the facility design capacity. For example, if three transmission lines are associated with two water source facilities, and if the first two transmission lines provide sufficient capacity to transmit all water that could be supplied by the associated sources, then only those two transmission lines would be brought into operation. The limitations inherent in this procedure prevent the program from being able to properly implement parallel, series, or combined systems of transmission lines. In those cases, the implementation schedule for the transmission lines should be entered by the user.

A cost generating segment contained in the program is used to develop the cost scenario for a series of water supply facilities. The program


```

30 Q=TGAL
   IF(TGAL.GT.MWR) Q=MWR
   IF(MWR.GT.AVSPY(II,KK)+ADD) Q=AVSPY(II,KK)+ADD
   IF(Q.GT.TGAL) Q=TGAL
   IF(AVSPY(II,KK)+ADD+Q.GE.TDPY(II,KK)) GO TO 80
   IF(NCONT.GT.NSORC) GO TO 80
35 IF(SUPPLY(NCONT).EQ.SUP) GO TO 70
   IF(TGAL.GT.MWR) GO TO 75
   IF(TGAL.GT.AVSPY(II,KK)+ADD) GO TO 75
   TGAL=SOURCE(NCONT)*365.+TGAL
   BUILT(NCONT)=YOD(II,KK)
   NCONT=NCONT+1
50 IF (TGAL-MWR) 30,30,60
60 IF (MWR+AVSPY(II,KK)+ADD,LT.TDPY(II,KK)) GO TO 35
   GO TO 80
70 ADD=SOURCE(NCONT)*365.+ADD
   BUILT(NCONT)=YOD(II,KK)
74 CONTINUE
   NCONT=NCONT+1
   GO TO 50
C   THE FOLLOWING OUTPUT SEGMENT IS CALLED IF THE ORDER IN WHICH THE
C   WATER SUPPLY SYSTEMS WERE READ IN WOULD NOT IMPROVE A WATER
C   DEFICIT SITUATION.  PROGRAM OPERATION IS TERMINATED.
75 IF(NCONT.GT.NSORC) GO TO 80
   NQ=(NCONT-1)*20+1
   NQ1=NQ+19
   WRITE(LUT,76)(SYSNAM(J),J=NQ,NQ1)
76 FORMAT(////,10X,'THE POSITION OF THE ',20A1,' IN THIS
   . SCHEME WILL NOT SERVE TO IMPROVE',/,10X,'THE WATER SUPPLY.  THE
   . PROGRAM WILL END SINCE FURTHER PROCESSING MAY PRODUCE MISLEADING
   . RESULTS.')
```

```

   GO TO 2000
80 SCPY(II,KK)=TGAL
```

Figure D-1.

generates individual costs of every facility on line for each year. Summary listings display the combined cumulative costs for all facilities at five-year intervals. Capital, Operation and Maintenance, and Total costs are presented on each page of the cost scenario. Average costs are displayed for five-year summaries. All costs are in terms of dollars per year and dollars per million gallons. A detailed description of the procedures used to develop these costs is given below.

Capital costs for each facility are calculated from the following variables: the plant capacity (QP) in MGD; the construction cost (CON) in dollars; an interest rate (RI); a capital cost recovery period (CCRP) in years; and a program determined percent utilization rate (QD) in MGD for each facility. An amortization factor is calculated from the interest rate and capital cost recovery period and applied to the construction cost to derive a capital cost. The following compound interest formula is used to determine the amortization factor (AF):

$$AF = RI (1. + RI)^{CCRP} / [(1. + RI)^{CCRP} - 1.] \quad (D - 1)$$

Capital costs are calculated by the following formulas:

$$\text{Capital Cost} = CON \times AF \quad (D - 2)$$

$$\text{Unit Cap. Cost} = CON \times AF / (QD \times 365) \quad (D - 3)$$

Equation D-2 yields capital costs in terms of dollars per year and equation D-3 yields capital costs in dollars per million gallons. It should be noted that when the period of time which a facility has been on line exceeds its CCRP, all capital costs are set to zero.

Operations and Maintenance costs are calculated from the following variables: the plant capacity (QP) in MGD; the unit O&M cost (O&M) in dollars/mil gal; a fixed annual O&M cost (FO&M) in dollars/year; an economy of scale factor (FACT); and the program determined average daily flow (QD) in MGD. The economy of scale factor (FACT) is used to develop a multiplier which serves to introduce an economy of scale effect to a facility as its utilization rate varies. The following equation displays the method in which FACT is used:

$$Y = (QD/QP)^{FACT} \quad (D - 4)$$

O&M = input unit O&M cost corresponding to plant utilization rate of 100 percent

Y = adjusted O&M cost

The adjusted O&M cost developed by equation D-4 and D-5 is an intermediate value. The unit value of the fixed O&M cost must be added to the adjusted O&M cost to arrive at the final value.

$$\text{Final unit O\&M} = \text{Adj. O\&M} + \text{FO\&M}/(\text{QD} \times 365) \quad (\text{D-5})$$

A dollars-per-year O&M cost is calculated by multiplying the adjusted O&M cost by the average yearly flow, and then adding to this product the fixed O&M cost.

$$\text{Final O\&M cost per year} = \text{Adj. O\&M} \times (\text{QD} \times 365) + \text{FO\&M} \quad (\text{D-6})$$

Total costs are calculated by the addition of the common Capital and O&M values. Total unit costs are then adjusted by a factor accounting for the amount of treated water that produces revenue (RPW) as follows:

$$\text{Total unit cost} = (\text{unit Cap.} + \text{unit O\&M})/\text{RPW} \quad (\text{D-7})$$

Cumulative costs for all dollars per year and dollars per million gallon values are simply summed for each year of the study. Average costs are calculated by summing the total amount of water supplied each year and dividing that into the total dollars expended.

Cost data generated in previous program segments is synthesized into a series of histograms. Time-investment patterns, established by the facility implementation schedules and the developed cost data, are graphically described by these diagrams. One page of output is sufficient to display the effects of varying plant efficiencies, capital depreciation, and the time-phased allocation of resources. Three histograms showing Capital costs, Operation and Maintenance costs, and Total costs are displayed in terms of dollars per year. In many cases, this output provides sufficient information for all practical uses. A series of output suppression devices can be activated to prevent part of or all of the cost scenario from being printed.

The Water Supply Program was written in Fortran for a PDP 11/70 mini-computer. Six subroutines, including the main program segment, were used to separate the program into functional sections (see Figure D-2). The main program segment is used exclusively to transfer control between the different subroutines. A Block Data subroutine is used to initialize all internal data values. All external data values are entered into the program by an input subroutine. An echo check of the data input is also outputted in this segment. Procedures for generating facilities' implementation schedules and the resulting flow values are contained in the fourth subroutine. All costs generated by the Facilities Selection Program are determined in the fifth subroutine. The sixth and last subroutine generates the histograms. An overlay for this program is necessary when running it on the PDP 11/70 computer. The time required to make a run similar to the case study described in the following section is about 20 seconds.

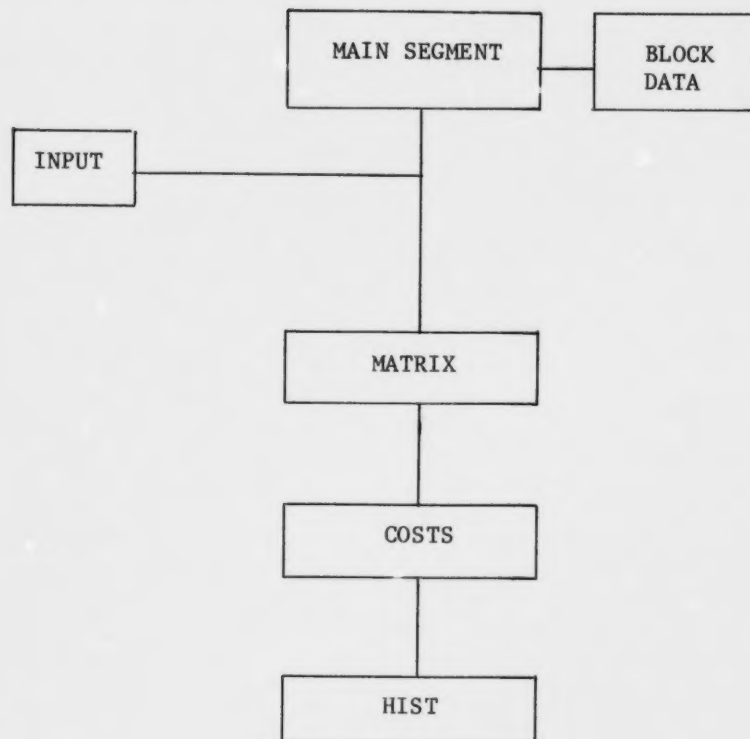


Figure D-2.

CASE STUDY

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To acquaint the user with an application of the program, a case study is presented based on an investigation of the impacts of providing additional water to the Dallas Water Utility. Three schemes for meeting the water needs of the Dallas service area through the year 2050 will be examined. The approach to be taken in this analysis will involve the use of the computer program to construct water flow and monetary cost scenarios for each of the schemes. These scenarios can then be compared in terms of demand satisfaction, efficiency of resource utilization, and cost economy. All costs calculated for the three schemes are for acquisition and do not reflect the expense, if any, for enlarging the capacity of the potable water treatment system.

Scheme I is a plan for expanding the water supply capabilities of the Dallas Water Utility through the use of conventional water supply techniques. A series of eight reservoirs and 15 transmission lines are selectively brought on line as the total water needs of the service area continue to increase. (The Tawakoni Lake reservoir and the Palestine Lake reservoir are considered to already exist and will therefore have no additional costs associated with them.) Figure D-3 graphically illustrates the resource development schedule for the water supply components of Scheme I. As the available supply of water (horizontal dashed line) begins to fall below the forecasted demand (concave dashed line), new sources of water (step function) are added to the system. Each rise in the step function identifies the point in time when the demand would overtake the pre-existing augmented available supply if new water sources were not added.

The scheduled implementation dates for the water facility and transmission components of Scheme I are displayed in Figure D-4. The water supply source schedule, located at the top of this figure, was determined by the optimization procedure in the computer program. This schedule corresponds to the step function shown in Figure D-3. The transmission line schedule, located under the source schedule, was entered by hand. Implementation dates for transmission lines were determined by assuming that if water from a particular source or sources is going to supply the needs of a specific area, sufficient transmission capacity must exist to pipe this water to its destination. Therefore, all transmission lines that are utilized by a water source must be brought on line with that source or before it. For example, the Lavon to Lewisville and Tawakoni to Lavon transmission lines were brought on line at the same time as the Tawakoni Lake reservoir to provide the necessary capacity for piping that water to the City of Lewisville. A map showing the water supply sources and transmission lines of Scheme I is displayed in Figure D-5.

A variety of flow data is calculated for this scheme based on the water source schedule in Figure D-4. These data are arranged and outputted in the form of a matrix which represents the water flow scenario for Scheme I (see Figure D-6). The first three lines of this matrix are the years, the demands, and the available supplies of water that were entered as part of the input data base. Line 4 of this matrix contains the combined capacity of all renovated wastewater treatment plants (RWW) on line. If

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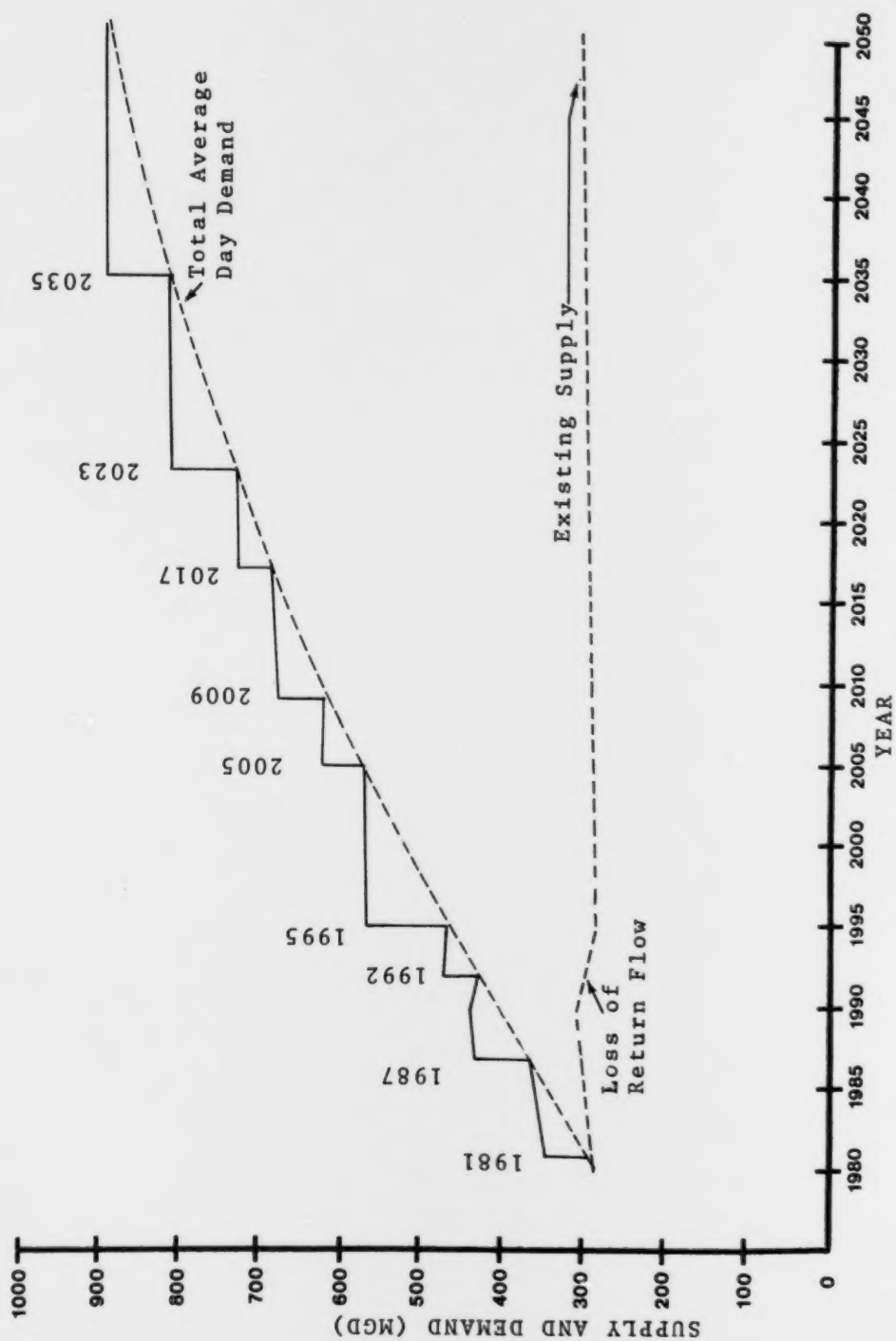


Figure D-3. Water Demand Scenario

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SCHEME 1 FOR DALLA WATER SUPPLY STUDY. OPTION 2T

WATER SUPPLY SOURCE SCHEDULE

SYSTEM NAME: LAKE TAWAKONI	CAPACITY(MGD): 64.0	YEAR ON LINE: 1981.
SYSTEM NAME: AURKEY RESERVOIR	CAPACITY(MGD): 60.5	YEAR ON LINE: 1987.
SYSTEM NAME: COOPER RESERVOIR	CAPACITY(MGD): 39.5	YEAR ON LINE: 1992.
SYSTEM NAME: LAKE PALESTINE	CAPACITY(MGD): 102.0	YEAR ON LINE: 1995.
SYSTEM NAME: SULFUR BLUFF I	CAPACITY(MGD): 53.7	YEAR ON LINE: 2005.
SYSTEM NAME: SULFUR BLUFF II	CAPACITY(MGD): 60.0	YEAR ON LINE: 2009.
SYSTEM NAME: MINEOLA RESERVOIR	CAPACITY(MGD): 45.0	YEAR ON LINE: 2017.
SYSTEM NAME: TENNESSEE COLONY	CAPACITY(MGD): 170.0	YEAR ON LINE: 2023.

TRANSMISSION LINE SCHEDULE

TRANSMISSION NAME: LAYON TO LEWISVILLE	CAPACITY(MGD): 120.0	YEAR ON LINE: 1981.
TRANSMISSION NAME: TAWAKONI TO LAYON	CAPACITY(MGD): 110.0	YEAR ON LINE: 1981.
TRANSMISSION NAME: HUNNARD TO E. SIDE	CAPACITY(MGD): 150.0	YEAR ON LINE: 1992.
TRANSMISSION NAME: COOPER TO LAYON	CAPACITY(MGD): 95.0	YEAR ON LINE: 1992.
TRANSMISSION NAME: PALESTINE TO E. SIDE	CAPACITY(MGD): 102.0	YEAR ON LINE: 1995.
TRANSMISSION NAME: SOUTHEAST TERMINAL	CAPACITY(MGD): 102.0	YEAR ON LINE: 1995.
TRANSMISSION NAME: SULFUR BLUFF-COOPER	CAPACITY(MGD): 220.0	YEAR ON LINE: 2005.
TRANSMISSION NAME: COOPER TO LAYON	CAPACITY(MGD): 212.0	YEAR ON LINE: 2009.
TRANSMISSION NAME: MINEOLA TO TAWAKONI	CAPACITY(MGD): 45.0	YEAR ON LINE: 2017.
TRANSMISSION NAME: LAYON TO LEWISVILLE	CAPACITY(MGD): 105.0	YEAR ON LINE: 2017.
TRANSMISSION NAME: BRISTOL INTERMEDIATE	CAPACITY(MGD): 170.0	YEAR ON LINE: 2023.
TRANSMISSION NAME: TENN. COL. - BRISTOL	CAPACITY(MGD): 95.0	YEAR ON LINE: 2023.
TRANSMISSION NAME: BRISTOL TO SE TENN.	CAPACITY(MGD): 170.0	YEAR ON LINE: 2023.
TRANSMISSION NAME: TENN. COL. - BRISTOL	CAPACITY(MGD): 95.0	YEAR ON LINE: 2023.
TRANSMISSION NAME: BRISTOL TO SE TENN.	CAPACITY(MGD): 170.0	YEAR ON LINE: 2023.

Figure D-4.

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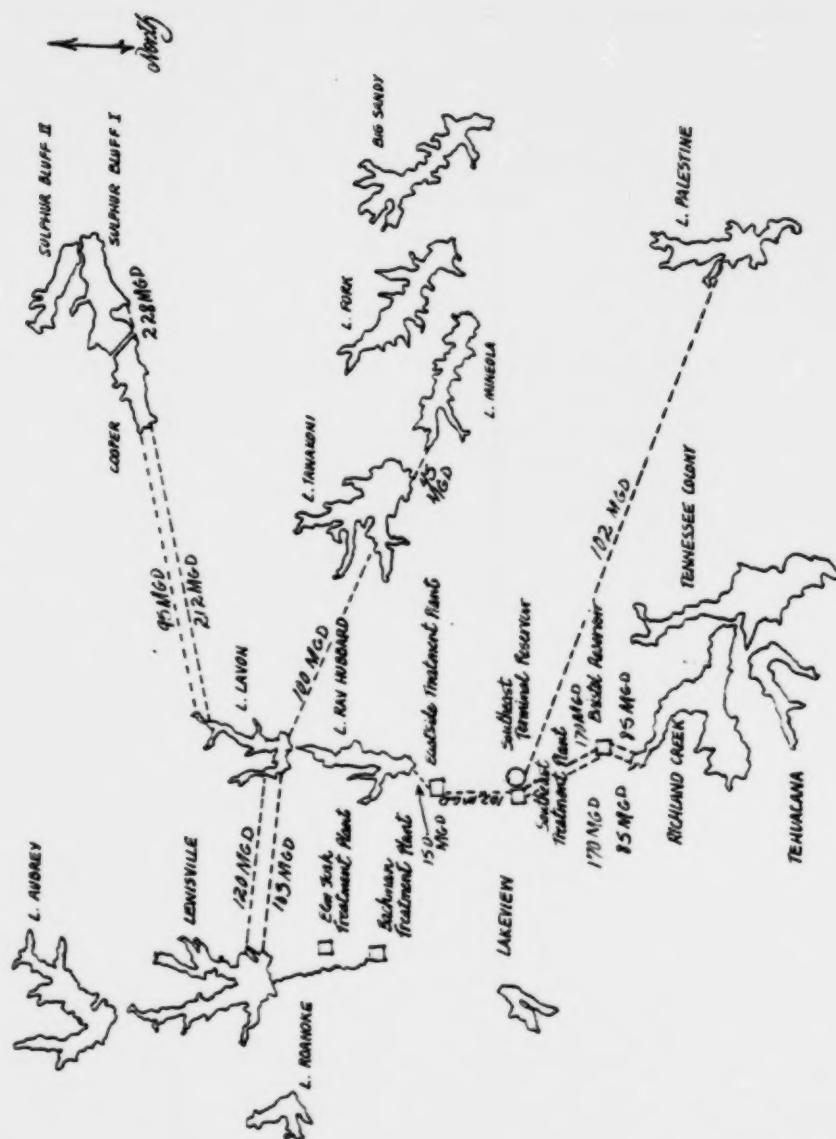
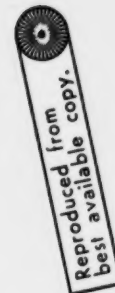


Figure D-5. Scheme I.

YEAR	1985	1990	1995	2000	2010	2015	2020	2025
WATER DEMANDED (IN M.G.)	105851	125825	147824	171551	188801	208049	229849	254551
AVAILABLE SUPPLY (IN M.G.)	105851	109913	113149	105851	105851	107875	107875	109500
ADVANCED WASTE TREATMENT CAPACITY (IN M.G.)	0	0	0	0	0	0	0	0
NON-AMT CAPACITY (IN M.G.)	0	23652	45735	97382	116982	138883	155308	217358
AVAILABLE SUPPLY + NON-AMT CAPACITY MINUS DEMAND (IN M.G.)	0	7240	11060	13432	16609	16609	16609	56758
REMOVED WASTE WATER (IN M.G.)	0	0	0	0	0	0	0	0
TOTAL AVAILABLE SUPPLY (IN M.G.)	105851	133165	150884	203233	224658	248383	264808	320858
TOTAL SURPLUS OR DEFICIT (IN M.G.)	0	7240	11060	13432	16609	16609	16609	56758
PERCENT CAPACITY AT WHICH TOTAL WATER SUPPLY SYSTEM IS RUNNING	0.0000	69.3845	75.8180	87.4661	86.2049	89.8026	88.0413	97.2412

Figure D-6.



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YEAR	2030.	2035.	2040.	2045.	2050.
WATER DEMANDED (IN M.G.)	284700.	293825.	306600.	317551.	326676.
AVAILABLE SUPPLY (IN M.G.)	111325.	111325.	111325.	113151.	113151.
ADVANCED WASTE TREATMENT CAPACITY (IN M.G.)	0.	0.	0.	0.	0.
NON-AWT CAPACITY (IN M.G.)	217350.	217350.	217350.	217350.	217350.
AVAILABLE SUPPLY + NON-AWT CAPACITY MINUS DEMAND (IN M.G.)	43983.	34850.	22083.	12950.	3833.
RENOVATED WASTE WATER (IN M.G.)	0.	0.	0.	0.	0.
TOTAL AVAILABLE SUPPLY (IN M.G.)	328683.	328683.	328683.	330509.	330509.
TOTAL SURPLUS OR DEFICIT (IN M.G.)	43983.	34850.	22083.	12950.	3833.
PERCENT CAPACITY AT WHICH TOTAL WATER SUPPLY SYSTEM IS RUNNING	79.7649	83.9631	88.8405	94.0386	98.2369

Figure D-6. (continued)

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zeros appear in line 4 it signifies no RWW plants are in use. The combined capacities of all other water supply sources that are not RWW plants are contained in line 5. Line 6 is the difference between the available supply in line 3 plus the non-RWW capacity in line 5 minus the demand in line 2. A negative sign in line 6 indicates that a deficit exists between the demand and the augmented available water supply. Line 7 contains the amount of recycled water that is drawn from the RWW system in line 4. The values displayed in line 8 are the summations of the available supply (line 3) plus the non-RWW capacity (line 5) plus the recycled water (line 7). These values represent the total amount of water that is supplied to the potable water treatment plants. Line 9 contains the difference between the total augmented available supply (line 8) and the demand (line 2). A negative value in line 9 indicates that a water deficit exists. The values contained in line 10 represent the percent of full capacity that the total water supply system has to operate at to just meet the demand.

The monetary cost scenario for Scheme I is presented in three parts. Figure D-7 contains a single page of the cost accounting sheets that comprise the first and most significant part of this scenario. One cost accounting sheet is generated for every year within the period of time defined by the study. This particular sheet is displayed since it contains costs for one of the years when all of the components of this scheme are on line. The zeros that appear in the Capital cost columns correspond to facilities that have exceeded their capital cost recovery periods (CCRP). Once the CCRP for a facility has been exceeded, all associated capital costs are set to zero for the remainder of the study. The column headings labeled "CRF" and "RPW" stand for Capital Recovery factor and Revenue-Producing Water. These values are calculated internally from the entered interest rates and amortization periods, and the entered revenue-producing water factors, respectively. The total cost column headed "\$/MG-RPW" implies that the RPW factor was divided into the total cost "\$/MG" value.

The second part of the monetary cost scenario consists of a series of cumulative and average cost pages generated at five-year intervals. Figure D-8 displays the last cumulative and average cost page produced for this study. As can be seen, under the total costs column, Scheme I has a total cost of 1,038,361,600 dollars and an average unit cost of 133 dollars per million gallons. The values displayed on this page should provide an important tool for evaluating and comparing the costs of the three water supply schemes discussed in this case study.

The final part of the cost scenario is a series of time-investment diagrams generated for Capital, Operations and Maintenance, and Total costs. All values used to develop those histograms are the sum total dollars per year costs that appear in the last row on each cost accounting sheet. Figure D-9 displays the total cost histogram generated for Scheme I. This figure provides an important visual aid for assessing economic impacts.

Scheme II is a water supply plan which utilizes renovated wastewater as a means of increasing the available water supply of the Dallas Water Utility. Effluent from municipal sewage treatment plants is upgraded by

COST ESTIMATES FOR WATER SUPPLY IN DOLLAR
YEARS 2050

WATER SUPPLY SOURCES	PERCENT CAPACITY FLOW (%) (MGD)	INT. RATE (YEARS)	CCRP (YEARS)	CFP (%)	DEM (%)	CAPITAL COSTS (\$/YEAR)	U&M COSTS (\$/MG)	TOTAL COSTS (\$/YEAR) (8/PG-PFV4)
Lake Tawaroni	100.00	84.8	.050	0.0	.000	0.00	0.00	0.00
Aubrey Reservoir	100.00	40.5	.050	30.0	.055	0.00	25.95	57,997.0
Coolin Reservoir	100.00	30.5	.050	30.0	.055	0.00	1.73	25,000.0
Lake Palestine	100.00	107.0	.050	30.0	.055	0.00	0.00	0.00
Sulphur Bluff I	100.00	51.7	.050	30.0	.055	0.00	4,001.0	4,001.0
Sulphur Bluff II	100.00	60.0	.050	30.0	.055	0.00	2.50	2,500.0
Mincola Reservoir	100.00	45.0	.050	30.0	.055	11,353.73	32,092.1	43,446.83
Tennessee Colony	93.82	170.0	.050	30.0	.055	115,046.6	20.07	144,166.0
TOTAL ACQUISITION COST						240,389.9	57.12	396,024.0
						192,135.0	57.11	396,024.0

TRANSMISSION Lines	PERCENT CAPACITY FLOW (%) (MGD)	INT. RATE (YEARS)	CCRP (YEARS)	CFP (%)	DEM (%)	CAPITAL COSTS (\$/YEAR)	U&M COSTS (\$/MG)	TOTAL COSTS (\$/YEAR) (8/PG-PFV4)
LAVON TO LEWISVILLE	98.75	120.0	.050	30.0	.065	0.00	15.43	66,559.0
TAWARONI TO LAVON	98.82	110.0	.050	30.0	.065	0.00	11.15	52,053.0
HARRARD TO F. KING	26.33	150.0	.050	30.0	.065	0.00	1.50	216.26
COOPER TO LAVON	41.58	95.0	.050	30.0	.065	0.00	11.59	16,421.0
PAULSTINE TO F. KING	100.00	102.0	.050	30.0	.065	0.00	20.82	197,806.0
SOUTHEAST TERMINAL	49.87	102.0	.050	30.0	.065	0.00	0.54	1,999.3
SULPHUR BLUFF-COOPER	49.87	228.0	.050	30.0	.065	0.00	8,782.0	8,782.0
COOPER TO LAVON	51.63	712.0	.050	30.0	.065	0.00	9.51	34,753.0
MINCOLA TO TAWARONI	100.00	45.0	.050	30.0	.065	0.00	11.51	18,002.0
LAVON TO LEWISVILLE	100.00	105.0	.050	30.0	.065	0.00	14.12	51,102.0
BRISTOL INTERMEDIATE	93.82	170.0	.050	30.0	.065	68,954.5	0.32	70,291.0
TERMS, COL. - BRISTOL	93.82	89.0	.050	30.0	.065	21,197.24	20.73	218,203.0
BRISTOL TO SE TERM.	93.82	170.0	.050	30.0	.065	73,057.8	2.43	87,279.0
TERMS, COL. - BRISTOL	93.82	89.0	.050	30.0	.065	21,197.24	20.73	218,203.0
BRISTOL TO SE TERM.	93.82	170.0	.050	30.0	.065	73,057.8	2.43	87,279.0
TOTAL TRANSMISSION COST						851,016.0	184.68	1,176,161.0
						519,101.1	184.68	1,176,161.0
SUM TOTAL COSTS						809,619.0	213.70	1,567,185.0
						667,916.7	213.70	1,567,185.0

Figure D-7.

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CUMULATIVE COST PAGE

ALL COSTS ARE CUMULATIVE OVER THE ENTIRE PERIOD OF THE STUDY AND ARE DISPLAYED AT FIVE YEAR INTERVALS.

CAPITAL COSTS		U+M COSTS		TOTAL COSTS	
(DOLLARS)	(\$/MG) AVG. (9/MG)	(DOLLARS)	(\$/MG) AVG. (8/MG)	(DOLLARS)	(\$/MG-RPW) AVG. (9/MG-RPW)
786271040.	90.	25209040.	29.	1038361400.	121733.
98507.		9835.		133.	
CUMULATIVE DEMAND TO THIS YEAR MG		16545466.			
CUMULATIVE AVAILABLE SUPPLY TO THIS YEAR MG		7783706.			
CUMULATIVE TREATED WATER TO THIS YEAR MG		8761761.			
CUMULATIVE WATER DEFICIT TO THIS YEAR MG		8761760.			
5 YEAR WATER DEFICIT MG		213525.			

Figure D-8.

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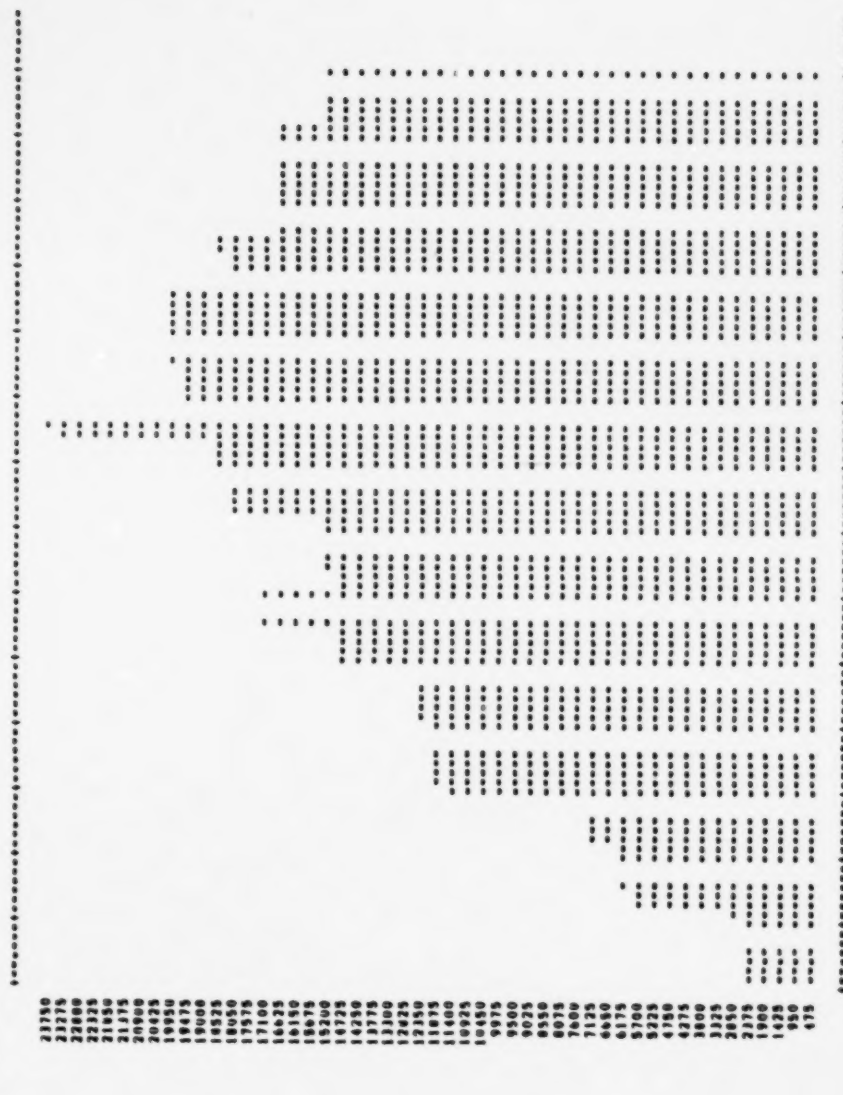


Figure D-9.

renovated wastewater methods and then piped to existing reservoirs. It is assumed that the following unit processes can be used to treat the secondary sewage effluent to an acceptable level.

- o Two-stage clarification
- o Mixed media filtration
- o Granular activated carbon (40 min. detention time)

The indirect reuse of renovated wastewater by piping it to existing reservoirs may also provide a degree of natural cleansing which serves to dilute or settle out contaminants that pass through the tertiary stage of sewage treatment.

A limit of 50 percent of the "demand water" per year may be allocated for advanced waste treatment and reuse. Demand water is defined as treated potable water. The use of renovated wastewater alone will satisfy the water needs of Dallas up to the year 2007. At that time, the demand will have equaled the existing available supply plus the total amount of recycled water that can be provided. Reservoirs are hereafter required to increase both the available supply of water and the amount of water available for renovation. Each additional reservoir is brought on line as the constraints placed on the use of recycled water are violated.

All water that is utilized by Scheme II is diverted from five advanced waste treatment plants and three reservoirs. Each of the RWW plants have design capacities of 100 MGD. Renovated wastewater is transported to Lake Ray Hubbard and Bachman treatment plants by two transmission lines. An additional two pipelines are used to transport water from the Tawakoni and Cooper reservoirs to the existing Lavon reservoir. A map, displayed in Figure D-10, shows the configuration of the water supply sources and transmission lines for Scheme II.

Schedules for implementing the components of Scheme II are shown in Figure D-11. These schedules were developed by the optimization procedure contained in the program. The associated transmission line schedule was developed by the program.

The water flow scenario for Scheme II is displayed in Figure D-12. An explanation of the significance of each row in this matrix can be found in the description of Figure D-6.

The cost scenario is illustrated by three figures. A typical cost accounting page, which is displayed in Figure D-13, shows the systems costs for Scheme II in the year 2050. When comparing this page to the costs shown for the same year in Scheme I, Scheme II does display the higher costs (see Figures D-7 and D-13). The final cumulative cost page, shown in Figure D-14, definitely substantiates the impression that the costs of Scheme II are far in excess of those for Scheme I. The total cumulative dollars cost for this Scheme is 1,465,227,904 dollars; the total average unit cost for this scheme is 188 dollars per million gallons. A graphical



Figure D-10. Scheme II.

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SCHEME 11 FOR DALLA WATER SUPPLY STUDY. OPTION 01

WATER SUPPLY SOURCE SCHEDULE

SYSTEM NAME: AWT PLANT #1	CAPACITY(MGD): 100.0	YEAR ON LINE: 1981.
SYSTEM NAME: AWT PLANT #2	CAPACITY(MGD): 100.0	YEAR ON LINE: 1991.
SYSTEM NAME: AWT PLANT #3	CAPACITY(MGD): 100.0	YEAR ON LINE: 1998.
SYSTEM NAME: LAKE TAWAKONI	CAPACITY(MGD): 64.8	YEAR ON LINE: 2007.
SYSTEM NAME: AWT PLANT #4	CAPACITY(MGD): 100.0	YEAR ON LINE: 2015.
SYSTEM NAME: AUBREY RESERVOIR	CAPACITY(MGD): 60.5	YEAR ON LINE: 2024.
SYSTEM NAME: AWT PLANT #5	CAPACITY(MGD): 100.0	YEAR ON LINE: 2039.
SYSTEM NAME: COOPER RESERVOIR	CAPACITY(MGD): 39.5	YEAR ON LINE: 2046.

TRANSMISSION LINE SCHEDULE

TRANSMISSION NAME: AWT TO RAY HUBBARD	CAPACITY(MGD): 216.0	YEAR ON LINE: 1981.
TRANSMISSION NAME: AWT TO EAST SIDE	CAPACITY(MGD): 216.0	YEAR ON LINE: 1998.
TRANSMISSION NAME: TAWAKONI PIPELINE	CAPACITY(MGD): 100.0	YEAR ON LINE: 2007.
TRANSMISSION NAME: COOPER TO LAVON	CAPACITY(MGD): 95.0	YEAR ON LINE: 2046.

Figure D-11.

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YEAR	1980.	1985.	1990.	1995.	2000.	2005.	2010.	2015.	2020.	2025.
WATER DEMANDED (IN M.G.)	105851.	125925.	147924.	171551.	189401.	208049.	229949.	244551.	259151.	270100.
AVAILABLE SUPPLY (IN M.G.)	105851.	109513.	113149.	105851.	105851.	107675.	107675.	109500.	109500.	109500.
ADVANCED WASTE TREATMENT CAPACITY (IN M.G.)	0.	36500.	36500.	73000.	109500.	109500.	109500.	146000.	146000.	146000.
NON-AWT CAPACITY (IN M.G.)	0.	0.	0.	0.	0.	0.	23652.	23652.	23652.	45735.
AVAILABLE SUPPLY + NON-AWT CAPACITY MINUS DEMAND (IN M.G.)	0.	-16412.	-34675.	-65700.	-83950.	-100374.	-98622.	-111399.	-125999.	-114866.
RENOVATED WASTE WATER (IN M.G.)	0.	16412.	34675.	65700.	83950.	100374.	98622.	111399.	125999.	114866.
TOTAL AVAILABLE SUPPLY (IN M.G.)	105851.	125925.	147924.	171551.	189401.	208049.	229949.	244551.	259151.	270100.
TOTAL SURPLUS OR DEFICIT (IN M.G.)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PERCENT CAPACITY AT WHICH TOTAL WATER SUPPLY SYSTEM IS FINNING	0.0000	44.9644	95.0000	90.0000	76.6667	91.6667	91.8304	79.6047	86.2106	83.7617

Figure D-12.

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YEAR	2030.	2035.	2040.	2045.	2050.
WATER DEMANDED (IN M.G.)	284700.	293825.	306600.	317551.	326676.
AVAILABLE SUPPLY (IN M.G.)	111325.	111325.	111325.	113151.	113151.
ADVANCED WASTE TREATMENT CAPACITY (IN M.G.)	146000.	146000.	182500.	182500.	182500.
NON-AWT CAPACITY (IN M.G.)	45735.	45735.	45735.	45735.	60152.
AVAILABLE SUPPLY + NON-AWT CAPACITY MINUS DEMAND (IN M.G.)	-127641.	-136766.	-149541.	-158666.	-153373.
RENOVATED WASTE WATER (IN M.G.)	127641.	136766.	149541.	158666.	153373.
TOTAL AVAILABLE SUPPLY (IN M.G.)	284700.	293825.	306600.	317551.	326676.
TOTAL SURPLUS OR DEFICIT (IN M.G.)	0.	0.	0.	0.	0.
PERCENT CAPACITY AT WHICH TOTAL WATER SUPPLY SYSTEM IS RUNNING	90.4245	95.1837	85.5589	89.5570	87.9964

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Figure D-12. (continued)

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COST ESTIMATES FOR WATER SUPPLY TO DALLAS
YEAR: 2050

WATER SUPPLY SOURCES	PERCENT CAPACITY FLOW (%) (MGD)	INT. RATE (YEARS)	CCRP RATE (YEARS)	CBF	RPW (%)	CAPITAL COSTS (\$/YEAR)	GM COSTS (\$/YEAR)	TOTAL COSTS (\$/YEAR) (8/MG-RPW)
ART PLANT #1	84.04	100.0	30.0	.085	0.89	0	3374206.	3374206.
ART PLANT #2	84.04	100.0	30.0	.085	0.89	0	3374206.	3374206.
ART PLANT #3	84.04	100.0	30.0	.085	0.89	0	3374206.	3374206.
LAKE TAWAKONI	100.00	64.8	0.0	.000	0.89	0	0.00	0.
ART PLANT #4	84.04	100.0	30.0	.085	0.89	0	3374206.	3374206.
AUDREY RESERVOIR	100.00	60.5	50.0	.055	0.89	3072001.	572997.	3644998.
ART PLANT #5	84.04	100.0	30.0	.085	0.89	2747173.	3374206.	6121379.
COOPER RESERVOIR	100.00	39.5	50.0	.085	0.89	314000.	25000.	359000.
TOTAL ACQUISITION COST						6153174.	17469028.	23622202.
						251.84	577.68	932.05
TRANSMISSION LINES	PERCENT CAPACITY FLOW (%) (MGD)	INT. RATE (YEARS)	CCRP RATE (YEARS)	CBF	RPW (%)	CAPITAL COSTS (\$/YEAR)	GM COSTS (\$/YEAR)	TOTAL COSTS (\$/YEAR) (8/MG-RPW)
ANT TO RAY HUBBARD	97.27	216.0	30.0	.085	0.89	0	719783.	719783.
ANT TO EAST SIOF	97.27	216.0	30.0	.085	0.89	0	997998.	997998.
TAWAKONI PIPELINE	64.80	100.0	30.0	.085	0.89	0	311024.	311024.
COOPER TO LAVON	41.58	95.0	30.0	.085	0.89	99675.	164230.	259305.
TOTAL TRANSMISSION COST						99675.	2192034.	2297110.
						6.59	46.93	60.14
RUN TOTAL COSTS						6248249.	19661062.	25909312.
						258.43	624.61	883.10

Figure D-13.

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YEAR = 2050

CUMULATIVE COST PAGE

ALL COSTS ARE CUMULATIVE OVER THE ENTIRE PERIOD OF THE STUDY AND ARE DISPLAYED AT FIVE YEAR INTERVALS.

CAPITAL COSTS		O+M COSTS		TOTAL COSTS	
(DOLLARS)	(\$/MG) AVG. (8/MG)	(DOLLARS)	(\$/MG) AVG. (8/MG)	(DOLLARS)	(\$/MG-RPW) AVG. (8/MG-RPW)
582432768.	22053.	66.	882794752.	28101.	101.
				1465227904.	56352.
					188.
CUMULATIVE DEMAND TO THIS YEAR MG		16545466.			
CUMULATIVE AVAILABLE SUPPLY TO THIS YEAR MG		7783706.			
CUMULATIVE TREATED WATER TO THIS YEAR MG		8761760.			
CUMULATIVE WATER DEFICIT TO THIS YEAR MG		8761760.			
5 YEAR WATER DEFICIT MG		213525.			

Figure D-14.

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illustration of the total costs for each year during the period of this study is contained in Figure D-15. This time-investment diagram can be used as a summary of the entire cost scenario.

Scheme III is also a water supply plant that utilizes renovated wastewater to augment the available water supply of the Dallas Water Utility. Effluent from municipal sewage treatment plants is upgraded to a higher degree than in Scheme II. This treated water is then piped directly to the headworks of the municipal potable water treatment plants. The following unit treatment processes are used to upgrade this water to the required levels:

- o Two-stage lime clarification
- o Mixed media filtration
- o Granular activated carbon (40 min. detention time)
- o Ozonation (40 mg/L O_3 feed rate)

It is assumed that by piping this water directly to the potable water treatment plant, a more reliable treatment train is established. In addition, since the water from RWW plants is available for immediate use, greater flexibility is exercised over the levels at which the plants operate.

As in Scheme II, a limit of 50 percent per year of the demand water may be allocated for advanced waste treatment and reuse. Reservoirs are, therefore, required to supplement that part of the demand which cannot be satisfied by renovated wastewater.

Five advanced waste treatment plants and three reservoirs are selectively brought on line to provide the Dallas Water Utility with enough water to meet the needs of its service area. Each RWW plant has a design capacity of 100 MGD. All water produced by these plants is transported by four transmission lines. Two of these lines go to the Bachman water treatment plant. A third transmission line connects the Bachman plant to the Elm Fork treatment plant. The fourth pipeline carries renovated wastewater to the East Side treatment plant. The Tawakoni and Cooper reservoirs are connected to the Lavon reservoir by the fifth and sixth transmission lines in this Scheme. A map displaying the water supply sources and transmission lines for Scheme III is contained in Figure D-16.

Water source and transmission line schedules for Scheme II are displayed in Figure D-17. An optimization procedure contained in the program was used to develop the source schedule. The transmission line schedule was also developed from a specific procedure contained in the program.

The water flow scenario for this scheme is displayed in Figure D-18. An explanation of the significance of each row in the matrix can be found in the description of the matrix for Scheme I.

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INTERVAL	1986	1988	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
100000/yr															
TOTAL COST	28450	27881	27312	26743	26174	25605	25036	24467	23898	23329	22760	22191	21622	21053	20484
	19346	18777	18208	17639	17070	16501	15932	15363	14794	14225	13656	13087	12518	11949	11380
	10811	10242	9673	9104	8535	7966	7397	6828	6259	5690	5121	4552	3983	3414	2845
	2276	1707	1138	569											

Figure D-15.



Figure D-16. Scheme III.

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SCHEME III FOR DALLA WATER SUPPLY STUDY. OPTION 01

WATER SUPPLY SOURCE SCHEDULE

SYSTEM NAME: ANT PLANT #1	CAPACITY(MGD): 100.0	YEAR ON LINE: 1981.
SYSTEM NAME: ANT PLANT #2	CAPACITY(MGD): 100.0	YEAR ON LINE: 1991.
SYSTEM NAME: ANT PLANT #3	CAPACITY(MGD): 100.0	YEAR ON LINE: 1998.
SYSTEM NAME: LAKE TAVAKONI	CAPACITY(MGD): 64.8	YEAR ON LINE: 2007.
SYSTEM NAME: ANT PLANT #4	CAPACITY(MGD): 100.0	YEAR ON LINE: 2015.
SYSTEM NAME: AURPEY RESERVOIR	CAPACITY(MGD): 60.5	YEAR ON LINE: 2024.
SYSTEM NAME: ANT PLANT #5	CAPACITY(MGD): 100.0	YEAR ON LINE: 2039.
SYSTEM NAME: COOPER RESERVOIR	CAPACITY(MGD): 39.5	YEAR ON LINE: 2046.

TRANSMISSION LINE SCHEDULE

TRANSMISSION NAME: NW TO EAST SIDE	CAPACITY(MGD): 150.0	YEAR ON LINE: 1981.
TRANSMISSION NAME: NW TO RACHMAN	CAPACITY(MGD): 150.0	YEAR ON LINE: 1991.
TRANSMISSION NAME: RACHMAN TO ELM FORK	CAPACITY(MGD): 150.0	YEAR ON LINE: 1998.
TRANSMISSION NAME: TAVAKONI PIPELINE	CAPACITY(MGD): 150.0	YEAR ON LINE: 2007.
TRANSMISSION NAME: NW TO RACHMAN	CAPACITY(MGD): 150.0	YEAR ON LINE: 2015.
TRANSMISSION NAME: COOPER TO LAVON	CAPACITY(MGD): 95.0	YEAR ON LINE: 2046.

Figure D-17.

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YEAR	2030.	2035.	2040.	2045.	2050.
WATER DEMAND (IN M.G.)	284700.	293825.	306600.	317551.	326676.
AVAILABLE SUPPLY (IN M.G.)	111325.	111325.	111325.	113151.	113151.
ADVANCED WASTE TREATMENT CAPACITY (IN M.G.)	146000.	146000.	182500.	182500.	182500.
NON-AWT CAPACITY (IN M.G.)	45735.	45735.	45735.	45735.	60152.
AVAILABLE SUPPLY + NON-AWT CAPACITY MINUS DEMAND (IN M.G.)	-127641.	-136766.	-149541.	-158666.	-153373.
RENOVATED WASTE WATER (IN M.G.)	127641.	136766.	149541.	158666.	153373.
TOTAL AVAILABLE SUPPLY (IN M.G.)	284700.	293825.	306600.	317551.	326676.
TOTAL SURPLUS OR DEFICIT (IN M.G.)	0.	0.	0.	0.	0.
PERCENT CAPACITY AT WHICH TOTAL WATER SUPPLY SYSTEM IS RUNNING	90.4245	95.1837	85.5589	89.5570	87.9964

Figure D-18.

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The monetary cost scenario for Scheme III is described by three figures. A typical cost accounting page of this scheme is shown in Figure D-19. This page displays the projected costs for the water supply system in the year 2050. When this page is compared to the ones for the other two schemes, the costs in Figure D-19 are the greatest. The last page of the cumulative and average cost sheet (Figure D-20) also shows the highest costs of the three schemes. The total cumulative dollar cost for Scheme III is 1,913,103,360 dollars, the total unit cost is 245 dollars per million gallons. Likewise, the total cost histogram for this Scheme (Figure D-21) shows the most expensive time-investment pattern for the three schemes.

OVERVIEW

Two publications were used to supply the raw data for the input data bases of the three water supply schemes. These publications are Renovated Wastewater as a Supplementary Source of Municipal Water Supply: An Economic Analysis and Semi-Final Report on Long-Range Water Supply Study to Meet Anticipated Requirements to the Year 2050 for the City of Dallas, Texas. Scheme I originated in the latter report as one of a series of plans for providing Dallas with additional water. Schemes II and III were developed in the former report as a means of comparing the costs of supplying renovated wastewater with the costs of using the more traditional reservoir approach. Water supply and demand forecasts which originated in the Semi-Final Report were used in both the economic analysis and as part of the input data bases for this case study. It is the combination of the water forecasts and a single water supply scheme that comprise a data base for the water supply program.

Cost data used in the schemes can be divided into three categories: Construction costs, Fixed Operations and Maintenance costs, and Unit Operations and Maintenance costs. Construction costs include all factors that influence the initial investment for the facility (land, labor, materials, engineering, administration, etc.). Fixed O&M costs represent the non-capital costs that remain constant whether the plant is operating at peak capacity or not at all. For the purposes of this case study, all Fixed O&M costs have been set to zero. Unit O&M costs are those costs which are required to operate the facilities at utilization levels equivalent to design capacity. Other input data that have either direct or indirect effects on costs include: a factor that specifies the amount of treated water that produces revenue; the design capacities of the facilities (in MGD); an interest rate and amortization period for each facility; construction data (optional); and a factor for allowing economies of scale to appear in the O&M costs (optional).

COST ESTIMATES FOR WATER SUPPLY TO DALLAS
YEAR 2050

WATER SUPPLY SOURCES	PERCENT CAPACITY FLOW (%)	INT. RATE	CCRP DATE	CCRP YEARS	CFR	MPW (%)	CAPITAL COSTS (\$/YEAR)	G&M COSTS (\$/MG)	TOTAL COSTS (\$/YEAR) (\$/MG-RPW)
ART PLANT #1	84.04	100.0	.050	30.0	.065	0.89	0.	4571773.	167.46
ART PLANT #2	84.04	100.0	.050	30.0	.065	0.89	0.	4571773.	167.46
ART PLANT #3	84.04	100.0	.050	30.0	.065	0.89	0.	4571773.	167.46
LAKE TAMARONI	100.00	84.4	.000	0.0	.000	0.89	0.	0.	0.
ART PLANT #4	84.04	100.0	.050	30.0	.065	0.89	0.	4571773.	167.46
ADRIET RESERVOIR	100.00	60.5	.050	30.0	.055	0.89	3072001.	139.11	364698.
ART PLANT #5	84.04	100.0	.050	30.0	.065	0.89	4345438.	141.66	8917211.
COOPER RESERVOIR	100.00	36.5	.050	30.0	.055	0.89	114000.	23.17	359000.
TOTAL ACQUISITION COST							7781439.	303.94	31208102.
								23456862.	1209.82
TRANSMISSION LINES	PERCENT CAPACITY FLOW (%)	INT. RATE	CCRP DATE	CCRP YEARS	CFR	MPW (%)	CAPITAL COSTS (\$/YEAR)	G&M COSTS (\$/MG)	TOTAL COSTS (\$/YEAR) (\$/MG-RPW)
WM TO EAST SHIP	56.03	150.0	.050	30.0	.065	0.89	0.	223554.	8.19
WM TO RACHMAN	84.04	150.0	.050	30.0	.065	0.89	0.	287436.	7.02
BACHMAN TO FLM FOR	56.03	150.0	.050	30.0	.065	0.89	0.	127729.	4.08
TAMARONI PIPELINE	41.20	150.0	.050	30.0	.065	0.89	0.	207357.	9.85
WM TO RACHMAN	84.04	150.0	.050	30.0	.065	0.89	0.	287436.	7.02
COOPER TO LAYON	41.58	84.0	.050	30.0	.065	0.89	95075.	11.19	259305.
TOTAL TRANSMISSION COST							95075.	44.10	1392820.
								1297745.	96.96
SUM TOTAL COSTS							7866114.	816.99	32601122.
								24754608.	1246.89

Figure D-19.

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YEAR = 2050

CUMULATIVE COST PAGE

ALL COSTS ARE CUMULATIVE OVER THE ENTIRE PERIOD OF THE STUDY AND ARE DISPLAYED AT FIVE YEAR INTERVALS.

CAPITAL COSTS		O&M COSTS		TOTAL COSTS	
(DOLLARS)	(\$/MG) AVG. (\$/MG)	(DOLLARS)	(\$/MG) AVG. (\$/MG)	(DOLLARS)	(\$/MG-RPW) AVG. (\$/MG-RPW)
793674112.	30488.	91.	1119429120.	36911.	128.
				1913103360.	75729.
					245.
CUMULATIVE DEMAND TO THIS YEAR MG		16545466.			
CUMULATIVE AVAILABLE SUPPLY TO THIS YEAR MG		7783706.			
CUMULATIVE TREATED WATER TO THIS YEAR MG		8761760.			
CUMULATIVE WATER DEFICIT TO THIS YEAR MG		8761760.			
5 YEAR WATER DEFICIT MG		213525.			

Figure D-20.

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APPENDIX E

WATER UTILITY COST DATA

This appendix contains information collected from selected utilities in the Washington Metropolitan Area during the analysis. The baseline cost information from the participating utilities and other data, such as Potomac River flow and population projections, were utilized to complete the analysis in the main body of this report.

The historical cost information obtained from the Washington Metropolitan Area water supply utilities is arranged in a format developed under an earlier contract with the U.S. Environmental Protection Agency. This format, which includes specific narrative information and an 18-page computer printout, has been utilized in the analyses of over 60 water supply utilities across the country and provides cost information on a comparable basis for all phases of water supply and water utility's management.

The application of this data acquisition and analysis technique to the public water system of the District of Columbia proved to be a unique undertaking, as this system is considered by some to be two separate entities. Computer output documentation is provided which combines the Washington Aqueduct Division of the Corps of Engineers and certain elements of the District's Department of Environmental Services. Additional output separates the two units into two distinct and separate utilities.

Data gathering activities started with visits to each of the selected utilities in March and April of 1977, with revisits continuing into 1978 as necessary. The initial visit to each utility took five days. The first day was spent briefing the manager and department heads and coordinating the collection of financial cost and billing data. The second day was spent reviewing 10 years of cost information to assure consistency with the other water systems and positive correlation with utility's accounting records. Day three was spent obtaining system and treatment flows from operations department heads. The fourth day was used to secure narrative data, identify future demands, and institutional and financial arrangements of the particular utility. The fifth day was spent in reviewing the previous analysis, checking for completeness and accuracy of the data, and collecting requested data from department contacts. Data availability within the Washington Metropolitan Area water supply utilities was generally good with the exception of revenue-producing water within the D.C. Department of Environmental Services, and operational and maintenance cost information for specific distribution facilities within the large

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water systems. This last item prevented the complete analysis of water supply cost within distribution zones of the specific utilities involved. There was also some difficulty in determining depreciation costs for the Corps of Engineers operated Washington Aqueduct Division and elements of the D.C. Department of Environmental Services, since neither of these systems have historically used depreciation cost accounting and both are in the unique position of being able to raise capital through the U.S. Treasury. Capital costs from these two entities may be understated.

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WASHINGTON SUBURBAN SANITARY COMMISSION

The Washington Suburban Sanitary Commission (WSSC) is a public agency established by the Maryland General Assembly in 1918 to serve suburban Montgomery and Prince Georges Counties. One of its chief functions is the operation of the water supply system.

At the time of WSSC's creation, the sanitary district, served by the Commission, consisted of 95 square miles with a population of approximately 32,000. By 1975, the service area had grown to include about 1,000 square miles with a population of close to 1.2 million and a water consumption averaging 124 MGD. Page 2 of the WSSC System printout lists additional systems facts. Figure E-1 is a service area map of the WSSC system.

ORGANIZATION

The WSSC is led by a six-member commission composed of three members each from Prince Georges and Montgomery Counties, Maryland. Near the end of fiscal year 1976, the Agency was reorganized consolidating most functions under three major structural units.

The Bureau of Maintenance and Operations is responsible for water supply and wastewater operations; research, maintenance of systems and facilities, and materials management including purchasing, materials testing, warehousing, and shop functions.

The Bureau of Engineering is responsible for project planning, including capital programming; permits processing, plumbing inspection/regulation, systems flow monitoring/projection, and project feasibility/allocation reporting. This bureau is also responsible for design, including major project management, design of water, sewerage, and storm water control systems as well as general service facilities and right of way/site acquisitions. In addition, this bureau is also responsible for construction, including the installation and inspection of designed facilities.

The Bureau of Administration is responsible for administrative services, including customer service, personnel, safety and security, data processing, and claims and insurance functions. They are also responsible for finance including assessments and revenues, management, accounting, and capital finance functions. The three bureaus function under the General Manager.

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WASHINGTON SUBURBAN SANITARY COMMISSION FACILITIES MAP

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- ▲ Direction of water flow.
- ▨ WSSC service area.

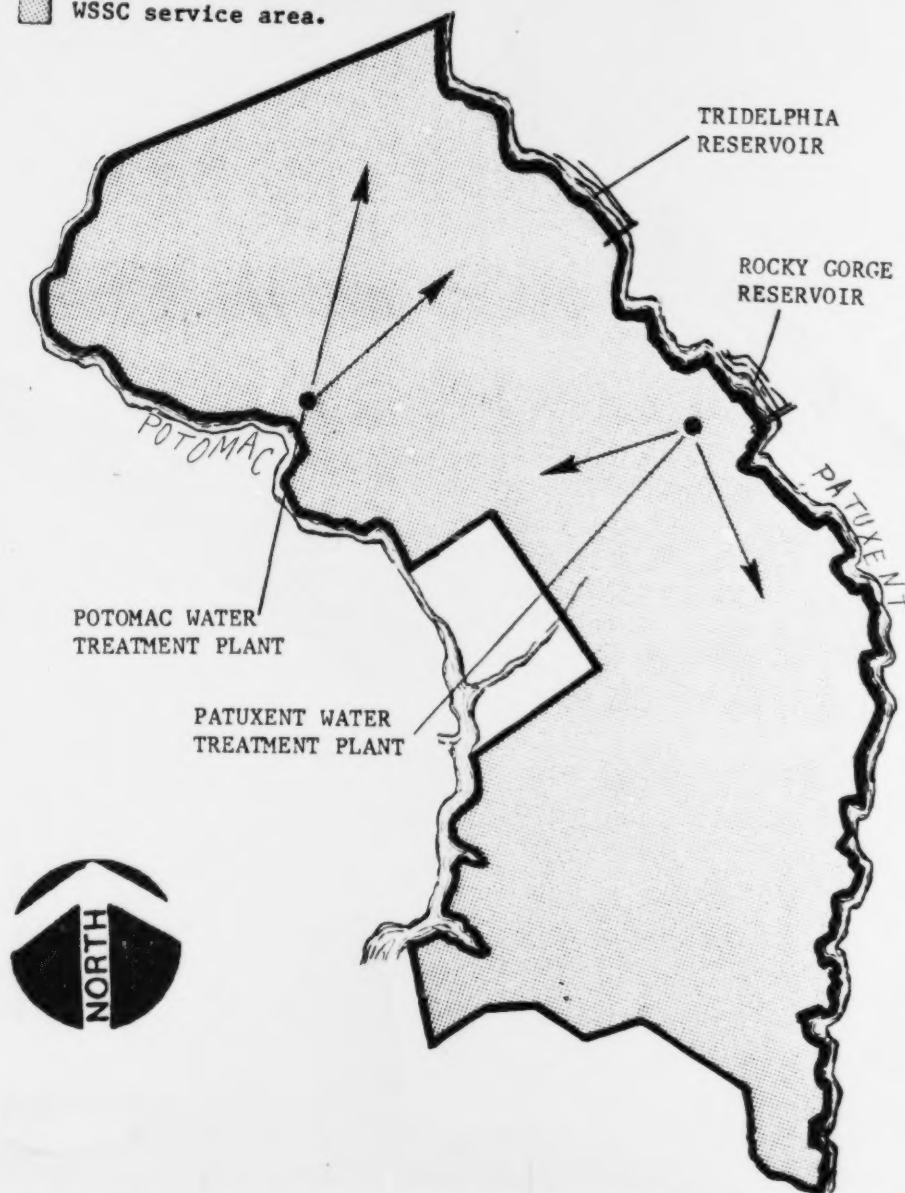


Figure E-1. Washington Suburban Sanitary Commission (WSSC) service area map.

Additionally, the Commission assigned five officers in the reorganized structure as a "dual reporting" unit responsible to both the General Manager and the Commissioners. The dual reporting unit includes budget, internal audit, equal employment opportunity, legal, and public affairs.

ACQUISITION

The principal sources of water supply for the WSSC are the Patuxent and the Potomac Rivers. The Patuxent River, winding along the northern borders of Montgomery and Prince Georges Counties, supports two water supply impoundment dams. They are designed as single purpose dams for water supply only. These two dams are located on the river at Brighton in Montgomery County, 14 miles north of the northernmost tip of Washington, D.C. and at Rocky Gorge, about two miles northwest of Laurel in Prince Georges County. The reservoir, located at Brighton, is known as the Triadelphia Lake and has a storage capacity of seven billion gallons. This lake is five miles long, has a water surface of about 800 acres, and is fed by a 50,000-acre watershed. Brighton Dam, 80 feet high and 995 feet long, was built between 1941 and 1943 at a cost of 2.3 million dollars.

The other reservoir, formed by the T. Howard Duckett Dam at Rocky Gorge, is approximately 13 river miles downstream from the Brighton Dam and has a capacity of 6.4 billion gallons. The watershed consists of 132 square miles or 84,500 acres. The lake is nine miles long and has a water surface of 800 acres. Construction of the 131-foot high and 840-foot long Duckett Dam was started in the spring of 1952 and completed in the summer of 1954 at a cost of approximately 3.0 million dollars.

The WSSC owns 6,000 acres of perimeter land around the two lakes and maintains it under strict soil-water conservation control. The property serves as a buffer against private development, and its existence helps keep this supply relatively free of siltation and pollution making it an exceptionally pure source of drinking water.

The second major source of water for Montgomery and Prince Georges Counties is the reservoirless Potomac River located along the western border of Montgomery County supplying over 27 billion gallons of water annually to the bicounty area. This river is the larger of the two sources of raw water for the WSSC service area. At this time, no raw water impoundment (reservoir) exists on the Potomac although there is a long-standing and definite need for such storage facilities on the river or its tributaries. The WSSC draws water from the river at a point located upstream from Great Falls near Potomac, Maryland.

TREATMENT

Located near each of the two rivers are water filtration facilities for converting the raw or unfiltered water into finished or drinking water of higher quality. Although both water plants produce the purest possible water for distribution to the WSSC service area, each uses a slightly

different treatment technique. Figure E-2 is a schematic of the systems water treatment facilities.

The older of the two facilities, the Patuxent water filtration plant, is situated about two miles from the Patuxent River near Laurel, Maryland. The plant has a production capacity of more than 65 MGD and was constructed in three stages. The first of four filter units was put into operation in 1944, the second in 1951, and the last two in 1955. Raw water is supplied to the filter plant from the Duckett reservoir. The Rocky Gorge pumping station, located near the dam, pumps the water from the reservoir through three parallel lines, sizes 30, 36, and 42 inches in diameter, to the filter plant. The plant itself is all of welded steel construction and consists essentially of a three-story head house, four filter units, and filtered water storage. The head house contains the office, laboratory, chemical feeding equipment, central control panel, storage rooms, and repair shop. The filter units are Morris-type design. This unique design was conceived by the first chief engineer of the Sanitary Commission.

The plant is composed of individual, circular-shaped units which contain mixing chambers, settling basins, six rapid sand filters, and the instruments, controls, and piping necessary for their operation. Each unit is independent of the others, and each may be put out of service without seriously affecting the overall plant operation. Treatment consists of prechlorination, coagulation, settling, filtration, corrosion control, and postchlorination or dechlorination.

The Potomac plant, which is located at River Road two miles upstream from Great Falls, also distributes water to both Montgomery and Prince Georges Counties. The Potomac filtration plant, which has a finished water production capacity of about 200 MGD, is of a more conventional design than the Patuxent plant, allowing for easy expansion. The first stage of this plant went into operation in 1961, and the facility has been expanded in subsequent stages to its current capacity. Ultimately, the plant is expected to have an output of up to 400 MGD. No raw water reservoir is presently available to the Potomac plant.

Treatment of water at the Potomac plant is basically the same as that provided by the Patuxent facility. Water begins to flow through the plant when it is received from the Potomac River through a man-made channel and flows through an intake structure, a concrete structure with large screens to remove floating debris. Next, the water travels under the C&O Canal by gravity through pipelines to the raw water pumping station which lifts the water with 1,500-horsepower pumps to the plant 140 feet above the river. On the way to the plant, the water passes through a Venturi meter which measures the flow and controls the rate at which the chemicals are added to the raw water. Carefully controlled automatic equipment adds chlorine to the water for disinfection, taste control, and odor control as it begins the treatment process. When the water enters the head house facilities, chlorine and alum are added as the water passes through the rapid mixing chamber. The water then moves to the flocculation basins for 30 minutes of slow mixing, and then to the settling basin where it remains

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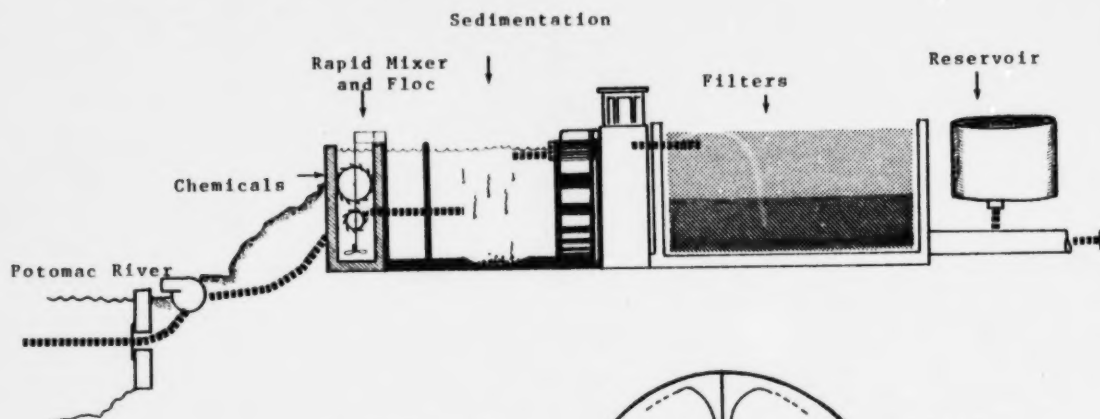
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WASHINGTON SUBURBAN SANITARY COMMISSION

POTOMAC RIVER TREATMENT FACILITY



PATUXENT TREATMENT FACILITY

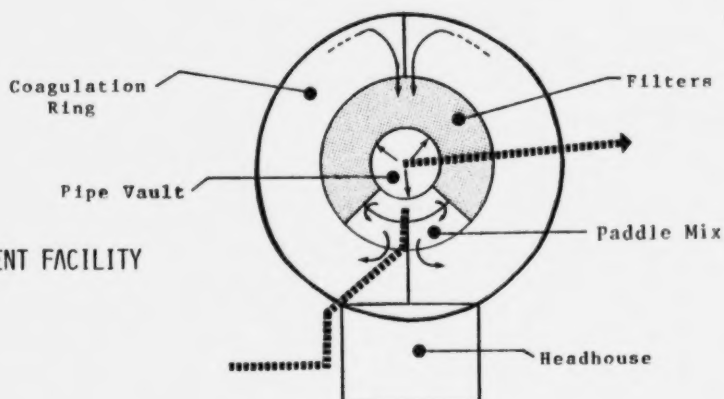


Figure E-2. Washington Suburban Sanitary Commission - treatment facilities diagram.

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for about 2-1/2 hours. The water passes through rapid sand filters and then to the filtered water reservoirs which have a storage capacity of 22 million gallons. Water is drawn from these reservoirs as needed, and pumped through the finished water pumping station through pipelines up to 96 inches in diameter.

DISTRIBUTION SYSTEM

Both the Patuxent and the Potomac plants feed finished water to the 3200-mile interconnected pipeline distribution system. This regional (bicounty) system does not differentiate between counties or specific localities; thus, many areas in the system receive a mixture of water from both plants. Most of the water produced at Patuxent flows to areas in Prince Georges County since these areas are lower in elevation than the plant. The difference in elevation allows the water to flow by gravity without the use of pumps. Water leaving the Patuxent plant for Prince Georges County flows through two feeder pipelines, 30 and 42 inches in diameter.

The portion supplied to Montgomery County from the Patuxent plant must be pumped since the Montgomery County area is generally at a higher elevation than the plant. Centrifugal pumps, located in a station at the Patuxent plant, force the water through 42-inch pipelines. This pumping station has a total capacity of 46 MGD. In addition, a 16-inch line supplies a small amount of water to Howard County. Water supplied to the area by the Potomac plant is delivered into two zones using two feeder pipelines, 36 and 60 inches in diameter. The high zone distributes water to the northern parts of Montgomery County including Damascus, Gaithersburg, and Norbeck. The main zone serves the central Montgomery County: Silver Springs, Wheaton, Chevy Chase, and Prince Georges County. Feeder pipelines to this zone are exceptionally large--48 inches and 96 inches in diameter.

In addition to the pipeline network, there are 49 water storage structures, low level reservoirs, standpipes, and elevated tanks located at various points along the distribution system. These structures have a total water storage capacity of 160.8 mil gal and are designed to meet peak customer requirements usually experienced in the morning and evening hours, and to provide a reserve supply for fire protection.

The three types of storage units are: 1) low level, steel or reinforced concrete tanks with the bottoms at ground level and relatively low profiles; 2) standpipe, a steel columnar structure normally filled by gravity flow from a feeder main and releasing water by gravity as needed; 3) elevated tank, a steel structure on legs releasing water through a gravity system. The standpipes and elevated tanks are usually located at high points on the public water system, and the structures make use of hydraulic pressure advantage of storage raised above the level of the tanks surrounding a service area.

The public water system in suburban Maryland includes about 23,000

fire hydrants installed at regular intervals along the route of the water distribution pipeline system. In all, close to 228,000 individual water services for homes, schools, apartment buildings, businesses, industrial structures, and government installations are connected to the WSSC's water distribution system in suburban Maryland.

COST ANALYSIS

Figure E-3 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, list the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the

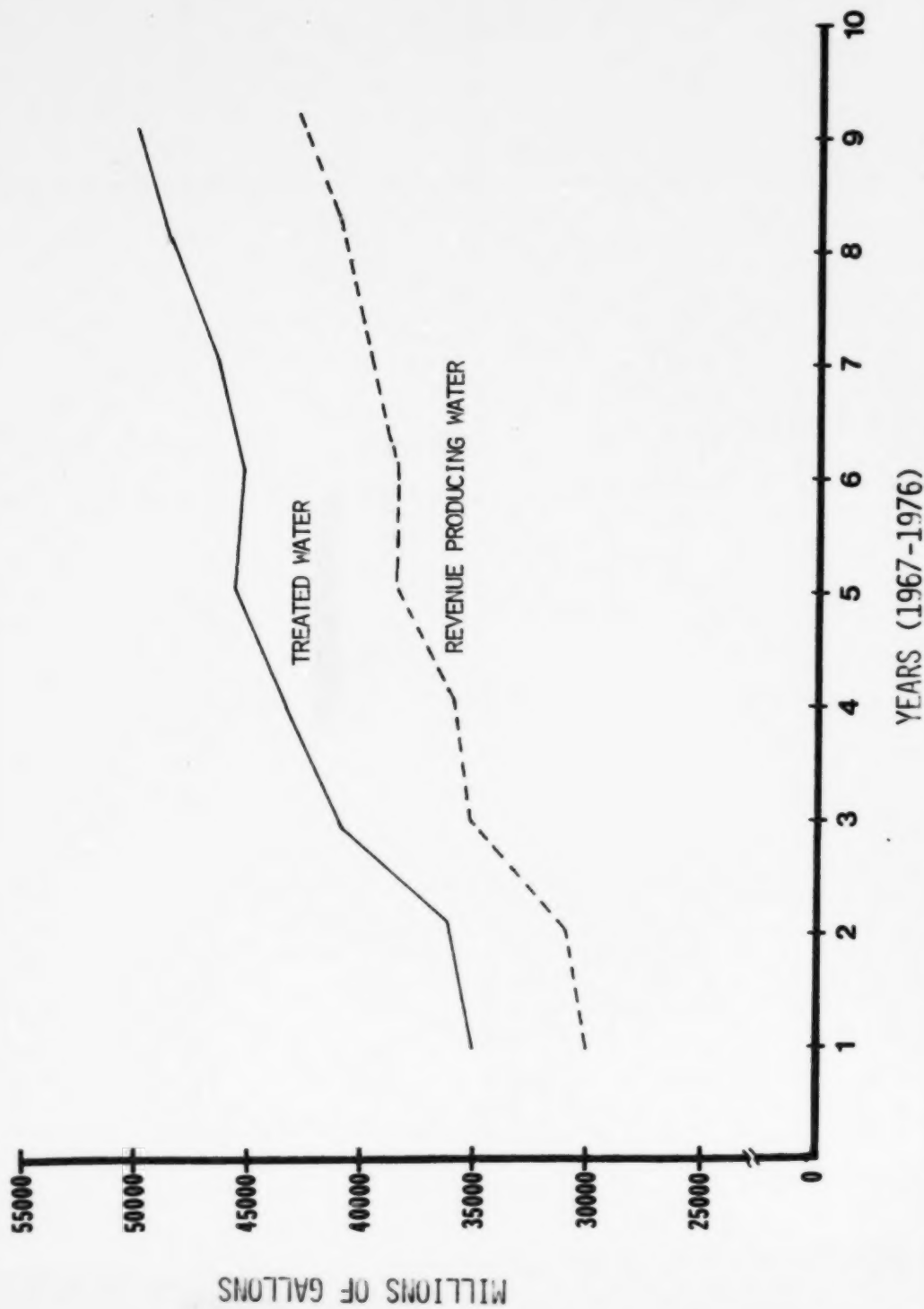


Figure E-3. Washington Suburban Sanitary Commission water flow: treated water vs RPW.

printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-4 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Washington Suburban Sanitary Commission is

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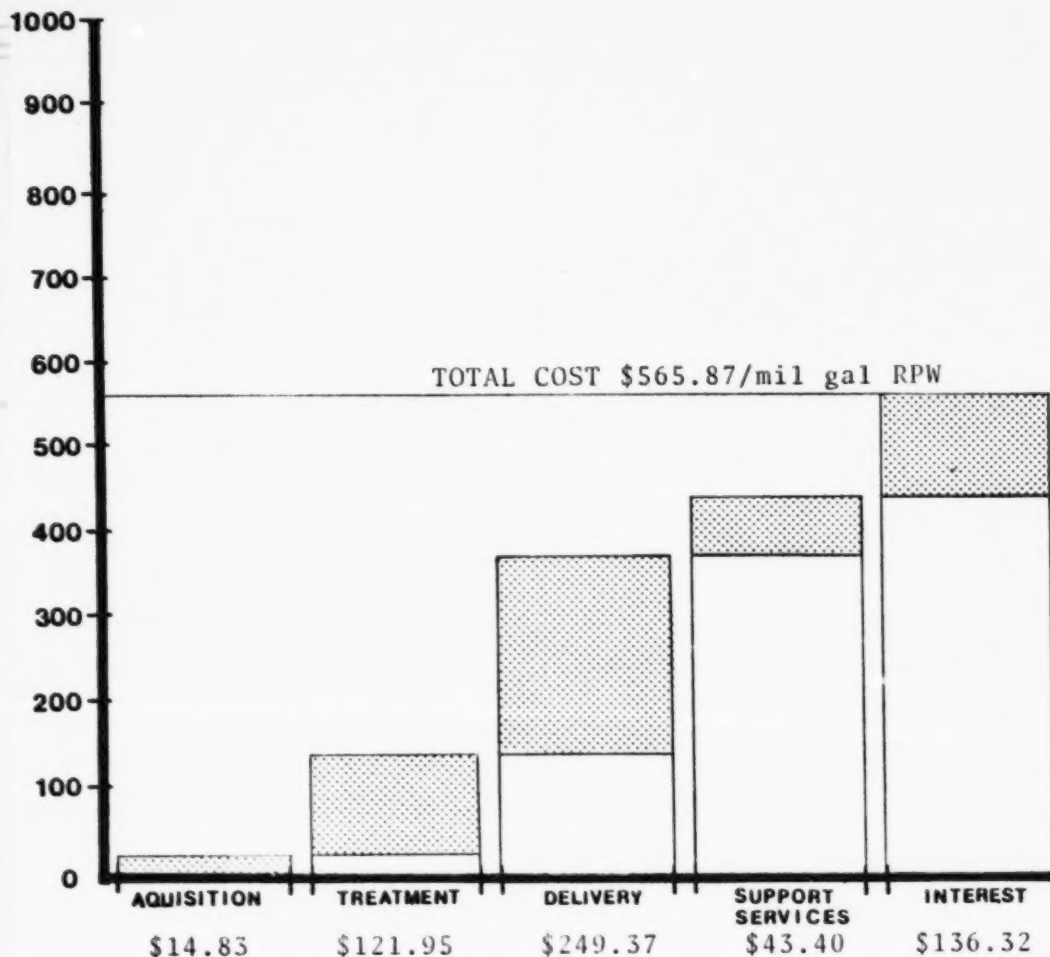


Figure E-4. WSSC allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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acquired at a cost of \$14.83/mil gal RPW. An additional \$121.95 is spent on the treatment of the water, as is \$249.37 for distribution. Support services and interest costs are also added, yielding a total cost of \$565.87/mil gal of RPW.

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PUBLIC WATER SYSTEM OF THE DISTRICT OF COLUMBIA

The Public Water System of the District of Columbia is a unique system and can be viewed from several perspectives. The Aqueduct Division of the U.S. Army Corps of Engineers and elements of the Department of Environmental Services, which is part of the District of Columbia government, make up the Public Water System. The following narrative describes the entire system and explains the responsibility of each of the two agencies. There are three cost printouts for the District of Columbia system included in this Appendix: Public Water System of the District of Columbia; D.C. Department of Environmental Services; and Washington Aqueduct Division of the U.S. Army Corps of Engineers.

ORGANIZATION

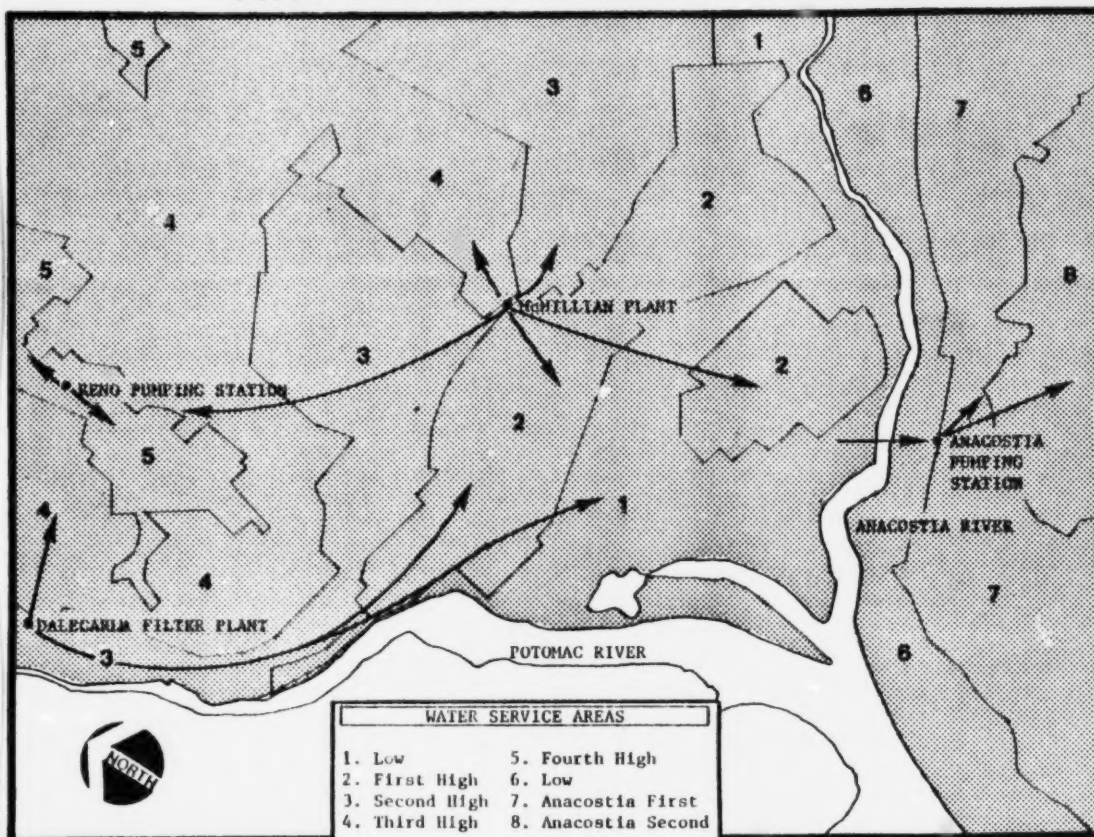
The water supply system of the District of Columbia is divided into two separate divisions--supply and distribution. The supply function of the District of Columbia was given to the Secretary of War from December 30, 1850 to 1867, and thereafter to the Corps of Engineers, U.S. Army. The agency of the Corps, which performs the actual function of supplying the water, is known as the Washington Aqueduct Division. The supply system consists of the facilities required to collect the water from the Potomac River at its Great Falls and Little Falls intakes above Washington and to convey it to the City; filter, chlorinate, fluoridate, and pump a portion of it to the distribution system. This system, under the Corps' responsibility, includes diversion dams, conduits, reservoirs, filters, filtration plants, pumping stations, and transmission mains. Page 2 of the Washington Aqueduct Division system printout lists additional systems facts. Figure E-5 is a service area map of the District of Columbia system.

The distribution system consists of elements of the Department of Environmental Services (DES) which is one of 17 different operating departments and agencies of the District of Columbia government which is under the jurisdiction of the Congress of the United States. Water Operations Divisions receive, store, pump, distribute, and meter purified water furnished from the supply function which is operated by the Corps of Engineers. The facilities include pumping stations, reservoirs, tanks, trucks, and service water mains. Additions to the system are designed by the Design and Engineering Division and constructed by the Construction and Repair Division. The billing operation of water provided to the customers, including federal agencies, is conducted by the Office of Business Administration. From July 1, 1916 to date, all expenses of operation and maintenance have been paid from the water fund of the District of Columbia, which was established by Congress to receive the

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PUBLIC WATER SYSTEM OF THE DISTRICT OF COLUMBIA



■ D.C. service area.

▲ Direction of water flow.

Figure E-5. D.C. Water System service area map.

water revenues from the water consumed by the federal government, the District of Columbia, Arlington County, and Falls Church, Virginia, as well as loans from the U.S. Treasury for capital improvements. From July 1, 1927 to date, all expenses for construction have been paid from loans and revenues deposited in the fund.

ACQUISITION

The Potomac River, the third largest stream on the Atlantic Seaboard, is the source of water for Washington, D.C. The water supply intakes are located at Great Falls, Maryland, about 10 miles northwest of the D.C. boundary and at Little Falls, Maryland, approximately 1-1/2 miles upstream from Chain Bridge. At Great Falls, the river has a drainage area of 11,460 square miles which is slightly less than the combined areas of the States of Maryland and Rhode Island. The average discharge is 7,100 MGD at Great Falls, Maryland. The maximum water consumption at present, including that part of Maryland and Virginia supplied from the Washington purification plant, utilizes about 3 percent of the average flow.

The diversion dam at Great Falls is a rectangular masonry structure reinforced upstream with riprap. It is 2,877 feet long, 8 feet wide at the top, and 10 to 15 feet in height for the greater part of its length. The 12-inch-high flashboards on top of the dam maintain the surface of the intake pool at an elevation of 151.5 feet above mean sea level. Two screened intake structures feed the raw water conduits.

In June 1959, the Washington Aqueduct completed construction of a 1,500-foot diversion dam, intake works, and a pumping station at Little Falls. This facility provides an additional independent raw water supply. A rising tunnel 10 feet in diameter, 4,560 feet long, discharges into the Dalecarlia Reservoir. This remotely operated intake structure and pumping station has an installed capacity of 450 MGD and a future installed capacity of 600 MGD. A 36-inch reinforced concrete pipeline was built into the upstream face of the dam to serve Virginia areas.

Two conduits conduct river water by gravity to the Dalecarlia Reservoir. The old conduit, a part of the original system completed in 1863, traverses the nine miles between Great Falls and the Dalecarlia Reservoir with an additional two miles of conduit linking the Dalecarlia and the Georgetown reservoirs. This conduit is circular, nine feet in diameter, and constructed of two or three rings of brick or cement-rubble masonry. The slope is about nine inches per mile for the entire length. The conduit is under slight pressure at the upper end. The maximum capacity is 106 MGD. The new conduit, completed in 1926, parallels the old conduit between Great Falls and Dalecarlia. It is a horseshoe shaped ten feet by ten feet in section unreinforced concrete. Its hydraulic gradient is approximately the same as that of the old conduit.

The Dalecarlia Reservoir receives water from both conduits. It is 46 acres in area and has a usable capacity of 60 mil gal. It is located at the northwest D.C. boundary in the valley of Little Falls Branch. A dam across the northern neck of the reservoir creates a fore-bay at the

effluent of the raw water conduits. A remote controlled booster station lowers the water level in the fore-bay and raises the level in the reservoir proper. This induces greater flow in the conduits by increasing the head differential and also increases the head between the reservoir proper and the Dalecarlia filter plant, the Georgetown Reservoir, and the hydroelectric plant. The booster station consists of three main pumps, each of 108 MGD capacity, against a head of eight feet and a single unit of 21 MGD capacity. Water from the Little Falls pumping station is pumped directly to the main Dalecarlia Reservoir.

The Georgetown Reservoir is an earth embankment riprap-revetment sedimentation and storage reservoir, 42 acres in area with a usable capacity of 55 mil gal. This reservoir, originally intended only for use as a storage and distribution reservoir when the water supply was unfiltered, is now used as a sedimentation basin for water destined for the McMillan filter plant. Coagulant is added to the water in the conduit at Dalecarlia where sufficient turbulent energy is generated during flow to Georgetown to accomplish mixing of the chemicals and flocculation. The floc, formed in transit, settles in two sections of the reservoir which have paved floors. These sections are drained and cleaned periodically. Clarification continues during passage through the third section of the reservoir. Then the effluent from the reservoir passes through the Washington City Tunnel to the McMillan Reservoir. A conduit, seven feet in diameter, bypasses the reservoir for emergency use. The Washington Tunnel is four miles long, extending from the west Shaft at Georgetown Reservoir to the east Shaft at McMillan Reservoir. It is horseshoe shaped in section, 9 feet by 9.8 feet, and is constructed of brick and rubble masonry. The original gravity flow capacity was 75 MGD. This has been increased to 150 MGD by the installation of a pump in the east shaft.

The East Shaft Gatehouse of the tunnel is located at the southwest corner of the McMillan Reservoir. The East Shaft pumping plant consists of one vertical adjustable-blade impeller pump with a capacity of 150 MGD. This pump increases the head differential between the east and west terminals of the tunnel thus increasing the flow rate. The reservoir is earthen embanked with an area of 38 acres and a usable capacity of 100 MGD. This facility is used as a storage reservoir. The water from the East Shaft Gatehouse is introduced to the reservoir at the northeastern end through a circular conduit. This provides good water distribution and allows additional settlement during the passage through the reservoir to the pump intakes in the east bay. Water is lifted from the reservoir to the adjacent McMillan slow sand filters by three vertical, adjustable blade impeller pumps, each having a capacity of 75 MGD.

TREATMENT

The McMillan filter plant, completed in 1905, is one of the few large slow sand filtration plants still in use in the U.S. Originally rated at 75 MGD, plant improvements and modification of treatment operations have increased the capacity to 125 MGD. There are 29 slow sand filter beds with an area of one acre each and the necessary sand bins and regulator houses. There are also administrative and maintenance buildings. The

filters are of groined arch reinforced concrete construction with a sand depth of 20 inches supported by 12 inches of graded crushed stone. Figure E-6 is a schematic of the system's water treatment facilities.

Filtered water is collected by an underdrain system of six-inch and 12-inch pipes laid with open joints on the filter floor, feeding a 24-inch tile central collector. Twenty-inch effluent pipes with propeller meters deliver filtered water to the regulator houses. A large collector main intercepts the filtered water from the regulator houses and discharges it to the north chamber of two adjacent clear well basins connected in series and has a capacity of 33.2 mil gal. Filters are washed after filtering approximately 1,000 mil gal. A treaded, electrically operated, mechanical unit scrapes and washes the sand ejecting cleaned sand immediately behind the machine. The sand is raked with a tractor-drawn harrow between washings. Sand is deep-cleaned as necessary.

Pretreatment with aluminium sulphate and chlorine at Dalecarlia and subsequent sedimentation at Georgetown and McMillan reservoirs results in a turbidity as low as two to three parts per million in the water as it is applied to the McMillan filters. Fluoride is added to the McMillan raw water as it leaves Dalecarlia Reservoir. After filtration, the water is disinfected with chlorine and the pH is adjusted with hydrated lime.

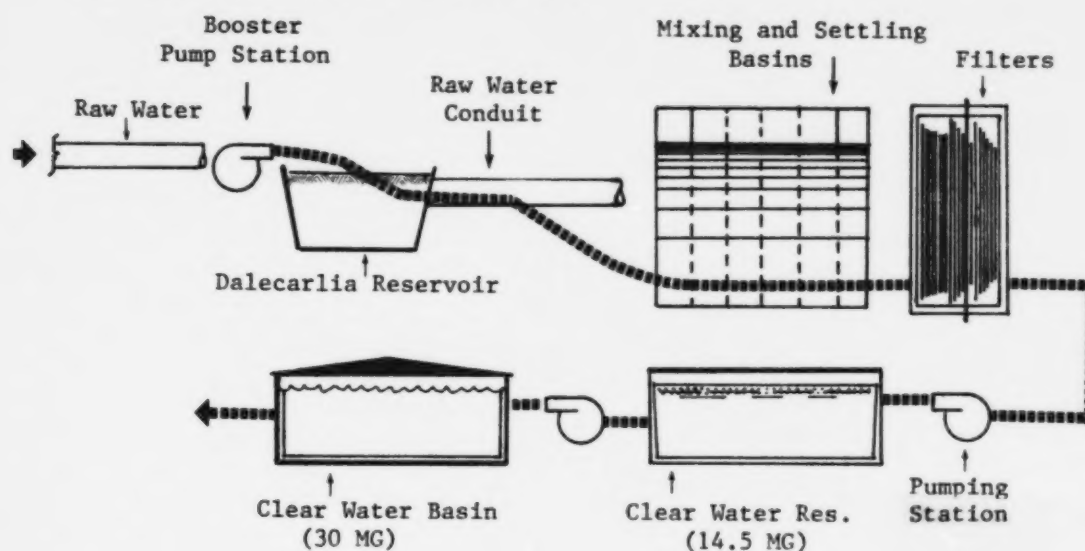
The covered clear well basins act as a suction well for the pressure services. When low service is not being pumped, the basins act as a distributing reservoir for that service area.

The Dalecarlia filtration plant is a rapid sand filter plant constructed in 1928 with a rated capacity of 80 MGD. Six additional filters, completed in 1951, increased the total rated capacity to 104 MGD. With the completion of the new filter and chemical buildings early in 1964, 21 new filters were added of which 10 have been equipped and placed in operation making the total rated capacity 164 MGD as of 1966.

This plant receives raw water from the Dalecarlia Reservoir. Chlorine is added to the raw water entering the plant to disinfect the water and to oxidize any organic matter. Chlorine residuals are maintained during flocculation, sedimentation, filtration and in the finished water going into the City. Aluminum sulphate, in the form of a liquid solution of crystal alum, is fed continuously to the raw water for removal of the suspended matter. Complete mixing of chemicals with raw water and flocculation occurs in the mechanical flocculation chambers located at the influent of the sedimentation basins. Removal of the alum floc together with the entrapped mud particles and bacteria takes place in the sedimentation basins. There are two concrete sedimentation basins each 335 feet long, 150 feet wide, and 12 to 17 feet deep with around-the-end diversion walls.

A two-story flocculation-sedimentation basin was added in the fall of 1949. The water encounters the two-story basin through distributing ports into the flocculation section which is part of the lower story. Flocculation is accomplished by six rows of paddles, 14 feet in diameter oper-

DALECARLIA TREATMENT FACILITY



McMILLAN TREATMENT FACILITY

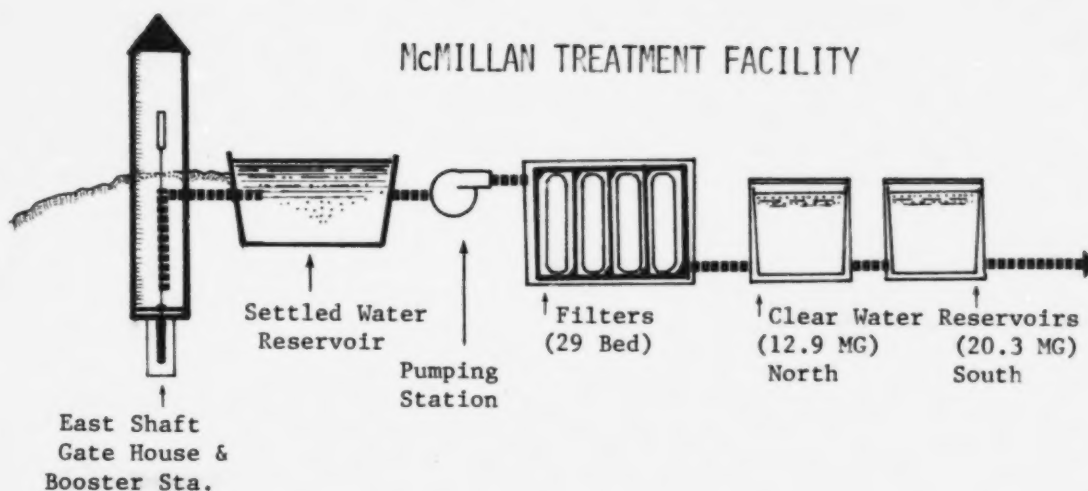


Figure E-6. Public Water System of the District of Columbia - treatment facilities diagram.

ated with axes transverse to the flow of water. From here, the water flows through the lower sedimentation section, then vertically upward and backward through the upper sedimentation section to the effluent channel. The capacity of the flocculation circulation section of the basin is 1.64 mil gal, and the retention period is 45 minutes with an average velocity of 2.6 feet per minute. The lower sedimentation basin is 316 feet long, 138 feet wide, and 17 feet deep. The upper basin is 460 feet long, 138 feet wide, and 15 feet deep with a total capacity of 12.1 mil gal. The retention period in the sedimentation section is 5.4 hours. These basins are flushed three or four times per year. Construction of the second two-story flocculation and sedimentation basin was completed in 1966. It is similar to the first in design and function.

From the sedimentation basins, the settled water flows by gravity to the rapid sand filters. Twenty-six of the filters have a rated capacity of four MGD and the new larger filters have a rated capacity of six MGD, all at a designed filtration rate of two GPM per square foot of filter surface area. Both sand and crushed anthracite coal are used as filter media. These filters are cleaned by backwashing with filtered water. Rotary surface sweeps are utilized during the backwash operation.

The filtered water may be postchlorinated, if necessary, to obtain desired residual chlorine in the finished water. Chlorine dioxide may be applied to remove objectionable taste and odor, and sulphur dioxide may be added to remove excess chlorine. Hydrated lime is added to adjust the pH and to control corrosion in the distribution system. Facilities for adding activated carbon are also available. Fluoridation of the water was begun on June 23, 1952.

The filtered and treated water is collected in covered concrete clear water basins. The original clear water basin at Dalecarlia has a capacity of 10.5 mil gal, and an additional 30 mil gal covered clear well basin was completed in 1954 increasing the total effective storage to 40.5 MGD. A new chemical building houses chemical unloading equipment, chemical storage and feed equipment, the control center, and a complete waterworks laboratory. The total filtration capacity of the plant as of 1966 was 164 MGD.

TRANSMISSION AND DISTRIBUTION

The Dalecarlia pumping station has a capacity of 477 MGD. The pump draws water from the 30-mil gal Dalecarlia clear well basins, and supplies purified water to four service level areas within the District of Columbia; and through those areas to metropolitan Maryland, to Arlington County, and Falls Church, Virginia. One additional pump supplies water to Virginia areas only. There are additional high service pumping stations at Bryant Street, Anacostia, and Reno. These stations have rated capacities of 310, 80.5, and 21.5 MGD respectively. As of 1966, there were 12 reservoirs and elevated tanks within the distribution system having a combined capacity of 110.24 mil gal. Table E-1 is a list of system storage facilities.

TABLE E-1. WASHINGTON D.C. WATER UTILITY SYSTEMS STORAGE

STORAGE FACILITY	ELEVATION (FEET ABOVE SEA LEVEL DATUM)	CAPACITY (MG)
Brentwood Park	172	25.00
Foxhall Road, Northwest	250	14.50
Soldiers Home, Northwest	250	15.00
44th & Van Ness Streets, Northwest	335	14.60
Reno, Northwest	424	5.40
Reno, Northwest	424	20.00
Reno, Northwest	485	.08
Reno, Northwest	485	.16
Ft. Stanton, Southeast	258	3.00
Ft. Stanton, Southeast	258	10.00
Good Hope Road, Southeast	382	0.5
Boulevard Avenue, Southeast	382	2.0

On June 30, 1956, the distribution system consisted of about 1,361 miles of water mains from two to 78 inches in diameter. In addition, the Federal government maintains and operates 12.3 miles of transmission mains within D.C. which deliver water to the first-high, second-high, and third-high reservoirs. Types of pipe include cast iron, ductile iron, reinforced and prestressed concrete, steel, and cement asbestos.

The service areas are generally interconnected through closed valves at all boundary intersections, permitting flexibility in supply from higher to lower service areas in emergencies.

COST ANALYSIS

Figure E-7 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW); and percent of total (the O&M cost per year as a percent of total cost per year).

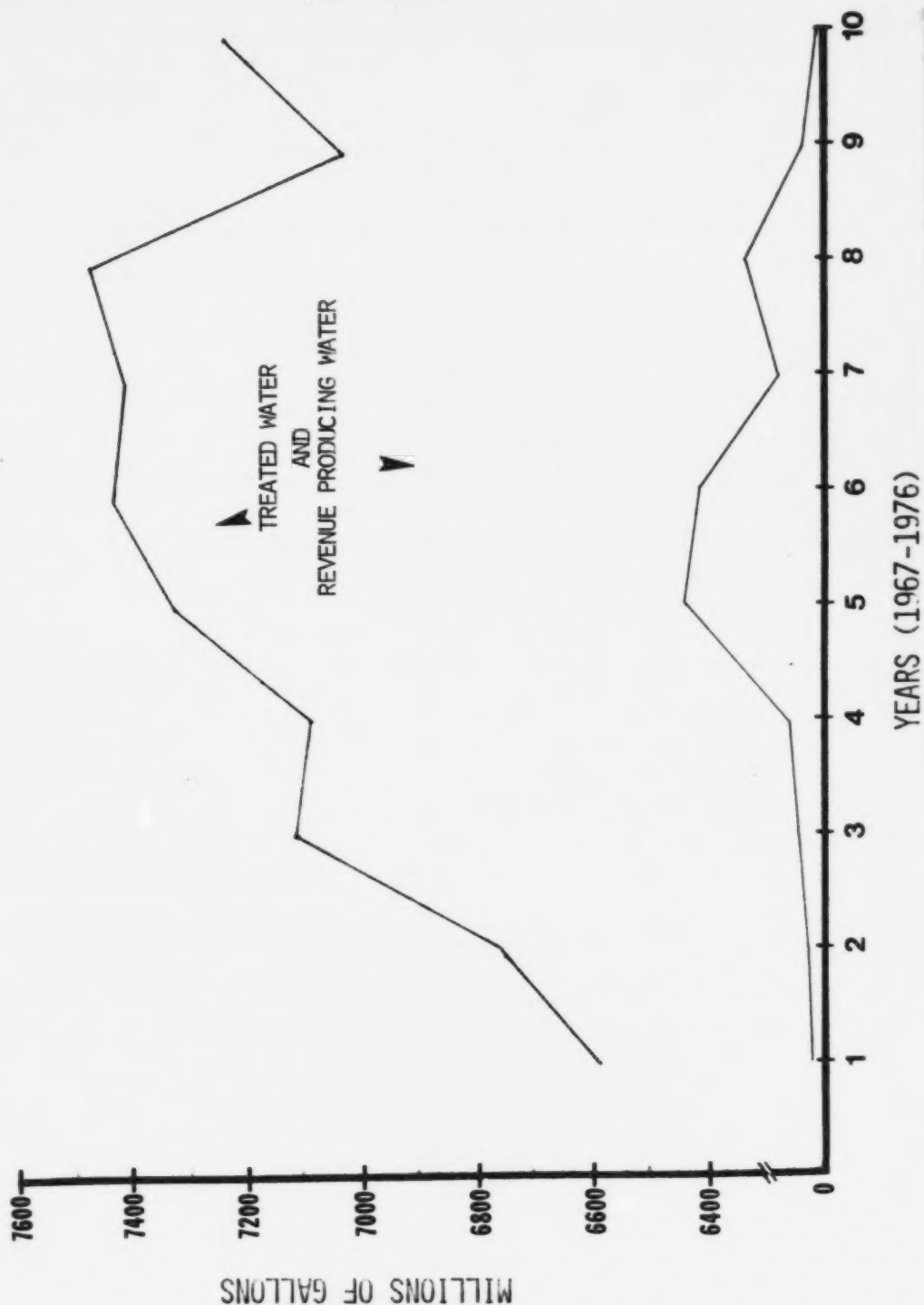
The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is

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Figure E-7. Public Water System of the District of Columbia
water flow: treated water vs RPW.

RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost, with taxes, of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-8 is a bar chart that shows combined operating and capital cost for each of the system's

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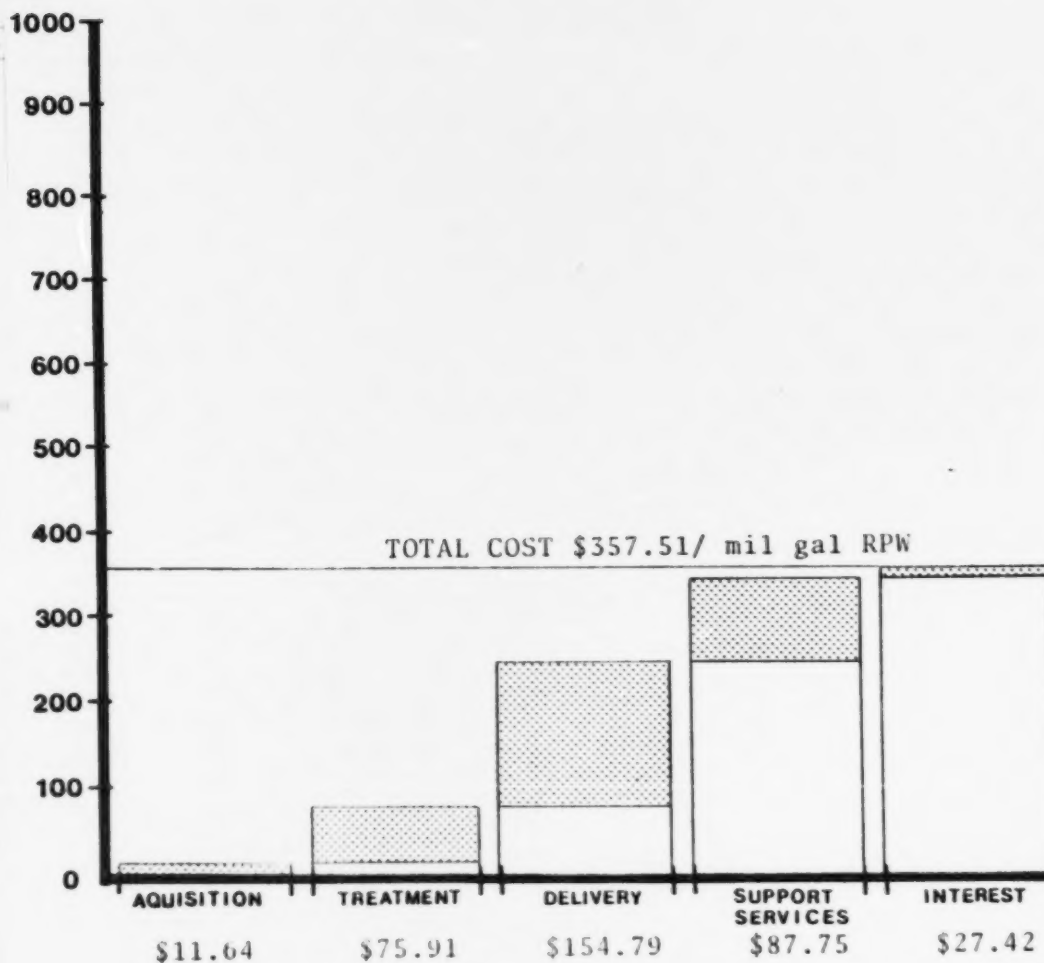


Figure E-8.

D.C. Public Water System allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Public Water System of the District of Columbia is acquired at a cost of \$11.64 mil gal RPW. An additional \$75.91 is spent on the treatment of the water, as is \$154.79 for distribution. Support services and interest costs are also added, yielding a total cost of \$357.51/mil gal of RPW.

PUBLIC WATER SYSTEM OF THE DISTRICT OF COLUMBIA ONE UTILITY OR TWO?

The previous analysis and documentation of the Public Water System of the District of Columbia combines activities of the Corps of Engineers and elements of the Department of Environmental Services (DES). It is possible, however, to determine costs for the Aqueduct Division and D.C.-DES as separate water utilities. Separate water supply cost study printouts are included in this report. The reader should use caution, however, in the interpretation of these data. In the Washington Aqueduct printout treated water and RPW are equal by definition. This system receives appropriations for all the water it produces. In the case of the D.C.-DES system's printout, treated water is equal to the Aqueduct's RPW. RPW for D.C.-DES is the amount of water actually sold and billed. For this reason, \$/mil gal figures in the printouts are not additive. For example, if one refers to total cost per year in dollars in the Washington Aqueduct printout and adds this to the comparable figure in the D.C.-DES printout, the total would be equal to the figure given in the Public Water System of the District of Columbia printout. However, if those same figures expressed in terms of mil gal RPW were added from the respective printouts, the resulting \$/mil gal figure would be lower than the corresponding figure on the D.C. Water System's printout due to the fact that no loss is considered in the analysis of the Aqueduct Division.

The water supply cost allocation of depreciation expense between the two systems was based on total dollar value of additions within recent years. Since neither D.C.-DES nor the Aqueduct Division maintains depreciation costs on their books, these can be considered an approximation.

THE WASHINGTON AQUEDUCT DIVISION OF THE U.S. ARMY CORPS OF ENGINEERS

The Washington Aqueduct Division of the U.S. Army Corps of Engineers is financed by direct appropriations from the Congress of the United States. Facilities operated by the Division include: water supply intakes at Little Falls and Great Falls; transmission facilities to convey the water to the Dalecarlia and McMillan treatment plants which filter, chlorinate, fluoridate, and pump a portion of the water to the distribution system. The Division operates diversion dams, conduits, reservoirs, filters, filtration plants, pumping stations, and transmission mains. These facilities are described in detail in the preceding section of this

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Appendix. The Appendix also includes an 18-page printout identifying the cost of operations.

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In 1976 the Aqueduct Division treated 72246 mil gal of water. The same figure is used as revenue-producing water to evaluate cost per mil gal of operations of the Aqueduct Division. During 1976 year acquisition cost was \$9.00/mil gal RPW, treatment was an additional \$58, distribution was \$22, and support services and interest were \$40 and \$10 per mil gal RPW respectively. Additional cost information for the years 1967 through 1976 may be found in the Aqueduct Division printout included in this Appendix.

D.C. DEPARTMENT OF ENVIRONMENTAL SERVICES

The District of Columbia Department of Environmental Services is one of 17 different operating departments and agencies of the District of Columbia government. The Department provides water, sewer, and sanitation services to the District. The Water Operations Division of the Department receives, stores, pumps, distributes, and meters purified water furnished by the Corps of Engineers. The facilities which the Department operates include: pumping stations, reservoirs, tanks, and water service mains. The Department also includes a design and engineering division, and a construction and repair division, which work on the water distribution system. Bills are sent out by the Office of Business Administration. A detailed description of transmission, storage, and distribution facilities operated by the Department of Environmental Services along with a map of the service area, may be found under the description of the Public Water System of the District of Columbia in this Appendix.

A separate cost printout also provided in the Appendix, identifies costs incurred by the Department of Environmental Services which may be allocated to water supply. In 1976 the Department received 72246 mil gal of treated water from the Corps of Engineers, Washington Aqueduct Division. That same year, 55355 mil gal produced revenue for the Department. This revenue was paid directly into the U.S. Treasury. Operating funds from the Department are from direct appropriations of the U.S. Congress. Cost figures for 1976 for the Department of Environmental Services include \$36/mil gal RPW for support services, \$0.00 for both acquisition and treatment as these functions are assumed by the Corps of Engineers Aqueduct Division which has been previously described, \$127/mil gal for distribution, \$15 for interest, yielding a total of \$178/mil gal RPW. Additional cost information for the years 1967 through 1976 may be found in the D.C. Department of Environmental Services printout included in this Appendix.

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ROCKVILLE WATER UTILITY

The Rockville Water Utility is owned by the City of Rockville, Maryland, and is operated under the Department of Public Works with some billing and administrative responsibilities assumed by other city departments. The utility serves the City of Rockville and a few customers in surrounding Maryland. Page 2 of the Rockville system printout lists additional systems facts. Figure E-9 is a service area map of the Rockville system.

ACQUISITION

The existing intake structure for the City of Rockville is located on the tow path of the Chesapeake and Ohio Canal about one and one-half miles upstream from the Great Falls Dam and about six-tenths of a mile downstream from Swains Lock.

The intake structure includes two screen channels and a wet well having a bottom elevation of 147 feet. There are three submersible pumps and two traveling screens, each in separate channels. Water enters the screens through 36-inch sluice gates and flows into the wet well. Trash racks or bar screens are provided at the river entrance to prevent logs and other debris from entering the intake. A motor operator controls one of the sluice gates at the river entrance to the screened channel. The motor operator is located in the highest level at floor elevation 170. The water level in the station is monitored by a telemetering device with the gauge in the filter plant, where a remote control is located to operate the sluice gate.

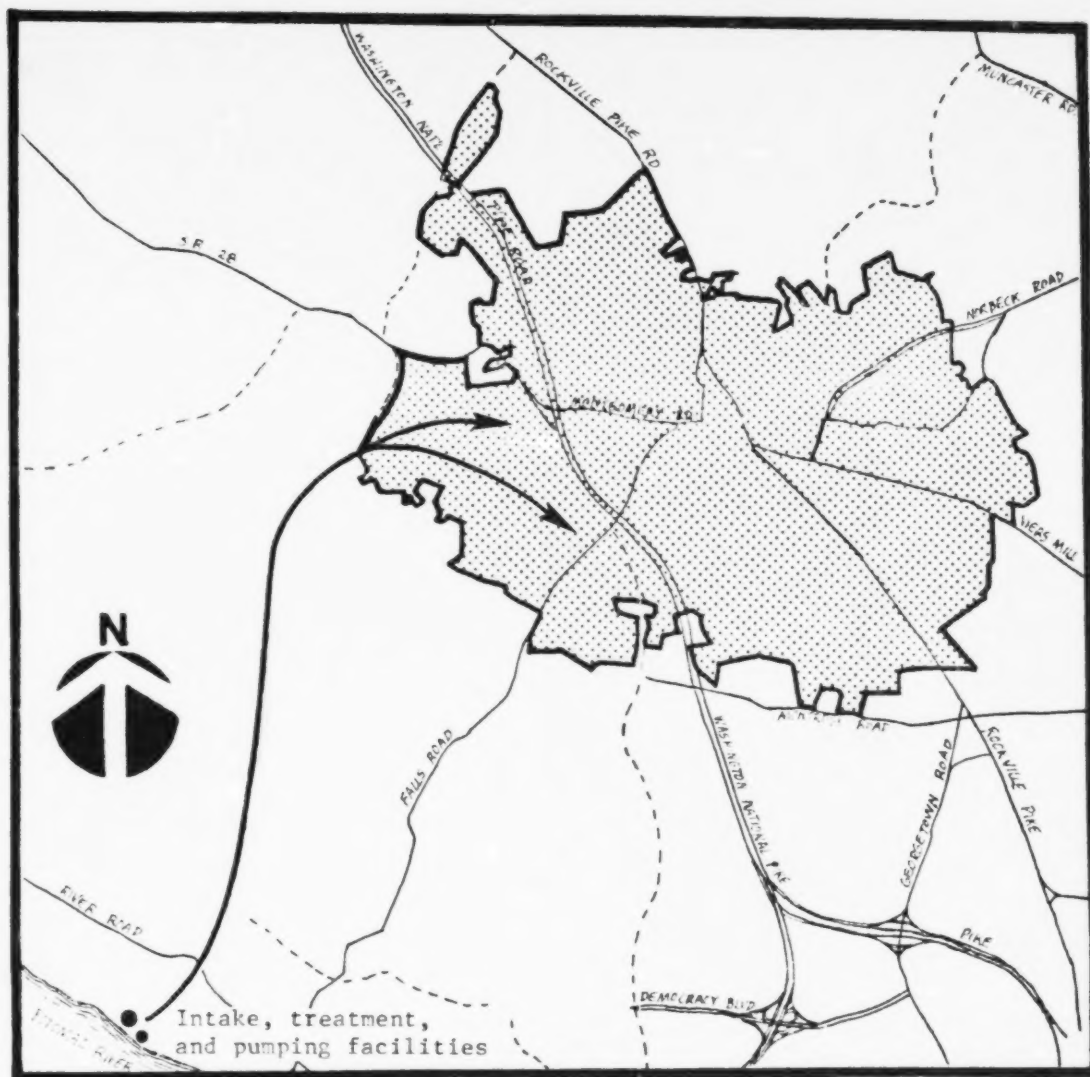
The calculated elevation of the water surface at the intake structure is approximately elevation 150 for extreme low flow under severe drought conditions. The crest of the Great Falls Dam, just downstream, is at elevation 150.5 with provisions for additional .5-foot flashboards or an elevation of 151.0. The City of Rockville takes water from this dam for water supply. The backwater from the dam controls low water at the intake which should be approximately elevation 151.

The pumping units in the existing intake structure comprise three submersible pumps each rated at a delivery of 3,100 gallons per minute at a total dynamic head of 114 feet. This head consists of the static head between the water surface in the wet well, and the water surface in the clarifiers in the treatment plant. The present capacity, assuming the 114 feet of total dynamic head, is 8.6 MGD at low water.

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ROCKVILLE WATER UTILITY FACILITIES MAP



Rockville service area.

Direction of water flow.

Figure E-9. Rockville Water Utility service area map.

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Presently, there are six interconnections with the WSSC water system, where the hydraulic gradient of the WSSC system is higher than that of the Rockville system. There is also one interconnection where the WSSC system's gradient is lower than that of Rockville, and here a booster pumps into the Rockville system. In addition, there are two interconnections where the City's gradient is higher than the Sanitary District's.

Of the six gravity interconnections three are on the west side, essentially serving local areas since the difference in hydraulic gradient is not great and the piping in the City is small. The booster pumped interconnection also serves a local area. The other three gravity connections are on the east side of the City, and here the hydraulic gradient of the WSSC system is approximately 110 feet higher than that of the City. While these are localized to some extent by the City's distribution piping, it is estimated that each could furnish about one MGD in an emergency. At least another MGD could be furnished by the other four interconnections for an estimated total of four MGD in an emergency.

TREATMENT

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The existing water treatment plant was placed in operation in 1958 and additional units added in 1967. The plant comprises two pretreatment units or clarifiers, four two-bay filters, and a three-story plant building with a clear well underneath containing a pipe gallery and pump room at ground level, an operating floor at the second level, and a storage room on the third floor. There is also a two-story chemical building with chemical feeding equipment on the first floor, and chemical storage bins on the second floor. The plant is located in a small draw or valley just off the Sandy Landing Road, a little over one-fourth mile from the intake structure. The present plant has a rated capacity of eight MGD. The eventual capacity, due to restricted space of the site, is approximately 12 MGD. Figure E-10 is a schematic diagram of the system's water treatment facility.

The clarifiers are of the up-flow contact basin type. Each is in a 53-square-foot tank with a water depth of 17 feet. Each unit has an average design flow rate of 2,800 gallons per minute or four MGD, and a maximum design flow rate of about 4,200 gallons per minute or six MGD. Each unit contains compartments or zones in one tank for mixing chemicals, flocculation, and settling. One unit has the sludge scraper mechanism collecting sludge at a center well. There are four filters with two bays each. Each bay is rated at a capacity of one MGD or eight MGD for the bank. Each filter is 41 feet by 21-1/2 feet in size. The filter rate is two GPM per square foot of filter area at rated capacity. Filter material is graded anthracite coal or "Anthrafilt" two feet in depth placed on four layers of graded gravel. The filters are equipped with hydraulic surface wash sweeps. The filters are open, and occasionally ice forms in them when they are not in use.

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The existing clear well is below grade under the pipe gallery of the plant building and is some 90 feet long by 30 feet wide by 10 feet deep,

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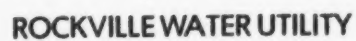


Figure E-10. Rockville Water Utility - treatment facilities diagram.

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and has a capacity of approximately 200,000 gallons. Backwashing is done by means of a wash water pump taking water from the clear well at a rate of 10,500 gallons per minute. There are three high service pumps, each rated at 2,800 gallons per minute, which pump water to the City of Rockville.

DISTRIBUTION

Presently, there are five storage facilities in the City of Rockville: one 8.0-mil-gal steel ground reservoir, one 3.0-mil-gal standpipe, one 0.4-mil-gal elevated steel tank, and two 1.0-mil-gal standpipes. Table E-2 is a list of system storage facilities.

COST ANALYSIS

Figure E-11 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll

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TABLE E-2. ROCKVILLE WATER UTILITY SYSTEMS STORAGE

STORAGE FACILITY	CAPACITY (MG)
Hunting Hill Reservoir	8.0
Carr Avenue Tank	3.0
Grandin Avenue Tank	.4
Talbott Street Tank	1.0
Horners Lane Tank	1.0

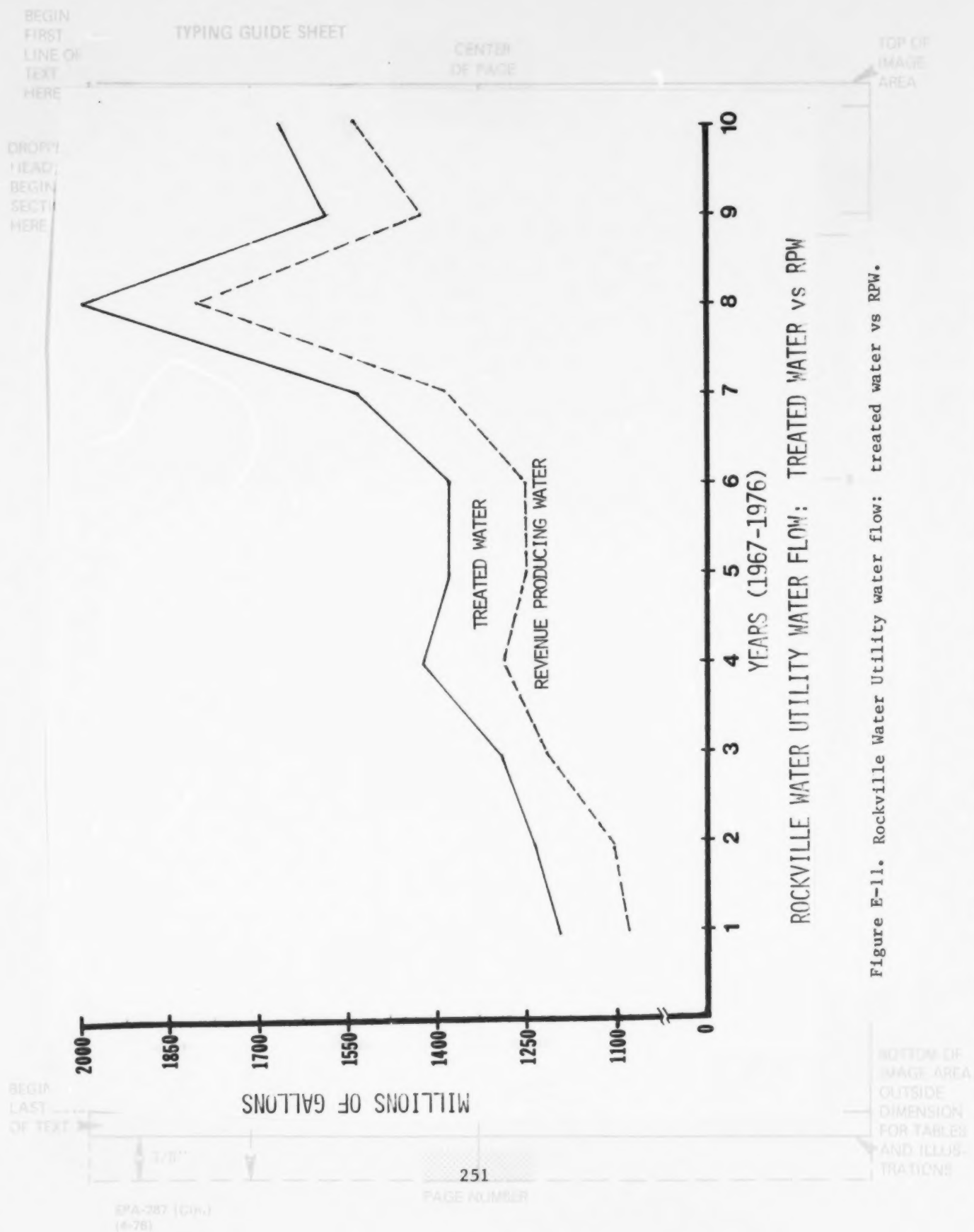


Figure E-11. Rockville Water Utility water flow: treated water vs RPW.

dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total cost in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and

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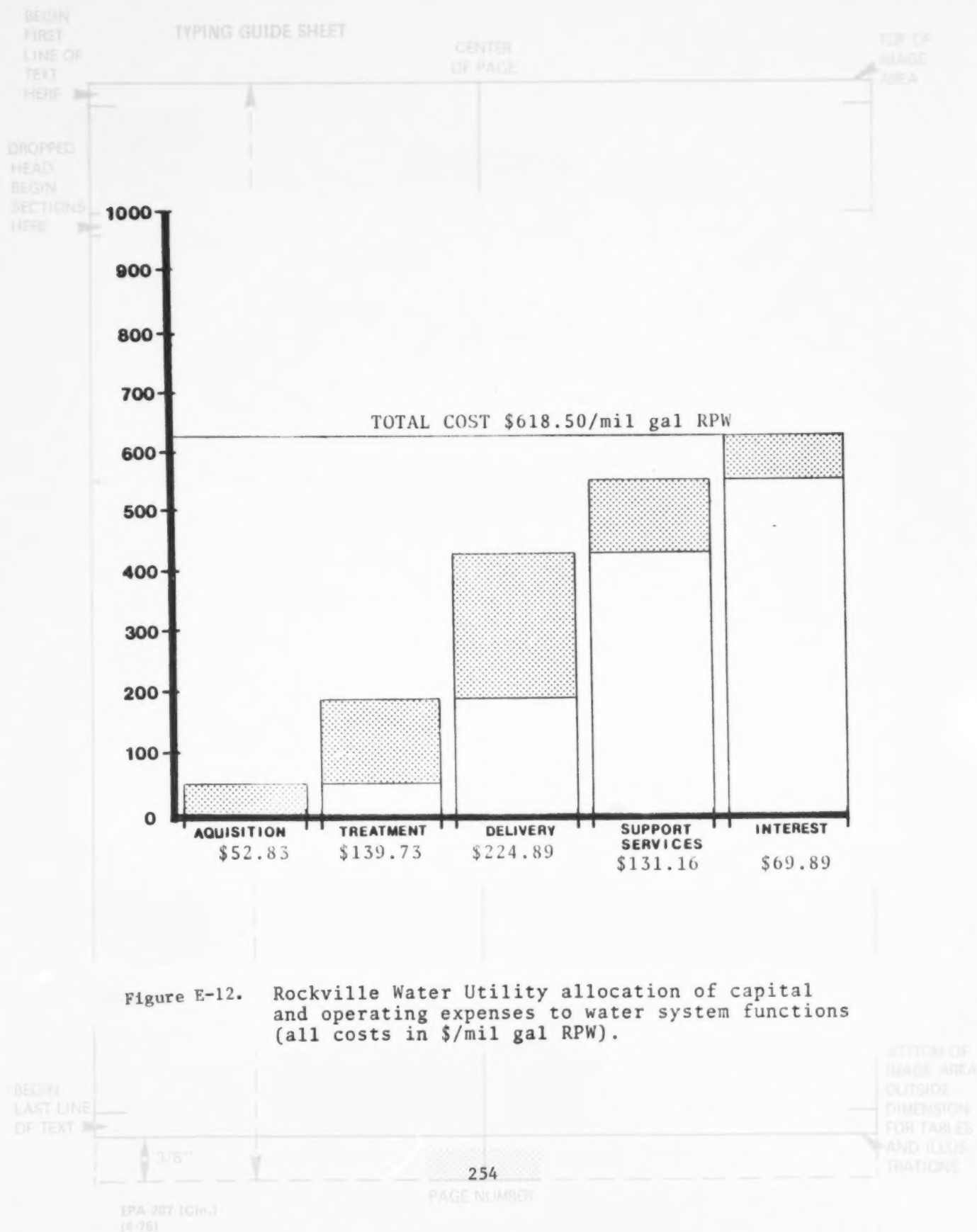
operating costs of the system's components. Figure E-12 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Rockville Water Utility is acquired at a cost of \$52.83/mil gal RPW. An additional \$139.73 is spent on the treatment of the water, as is \$224.89 for distribution. Support services and interest costs are also added, yielding a total cost of \$618.50/mil gal of RPW.

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FALLS CHURCH WATER SUPPLY

The first public water system was established in Falls Church in 1931. The water supply was pumped from wells into a tank constructed in 1934. In 1950 the City wells were no longer adequate to meet the demands of the increasing population and, through an agreement with Arlington, the City started taking water through a 24-inch connection to the Arlington County main at Chain Bridge. Arlington obtains its water from Dalecarlia via the crossing at Chain Bridge. It was stipulated in the agreement that the City would complete its own crossing and connections to Dalecarlia in 1961, at which time Arlington would need the full capacity of its mains at Chain Bridge. In 1962, Falls Church started taking water directly from Dalecarlia through a newly installed transmission main consisting of 11,413 feet of 36-inch pipe from Langley, Virginia, to the Dalecarlia Filter Plant on MacArthur Boulevard. The 24-inch connection to Arlington is kept intact for emergency use. Page 2 of the Falls Church Water Supply printout supplies additional systems facts. Figure E-13 is a service area map of the Falls Church system.

ORGANIZATION

The Department of Public Utilities has the responsibility of managing, operating, and maintaining the City's water and sewer systems. The systems are self-supporting and operate separately as a private enterprise paying an equitable sum to the City in lieu of taxes, rent of office space, and equipment, and paying for all services rendered by other departments.

ACQUISITION-TREATMENT

The Public Utilities Department buys treated water at a wholesale rate from the U.S. Army Corps of Engineers via a 36-inch connection to the Dalecarlia Filter Plant located in the District. The U.S. Army Corps of Engineers obtains its raw water from the Potomac River at Great Falls and at Little Falls.

Falls Church also purchases a small amount of water from Arlington County to serve some of its customers located in an area too high to be served by the Falls Church system. There are also emergency connections with the Fairfax County Water Authority.

DISTRIBUTION

The service area covers approximately 33 square miles, of which 31

FALLS CHURCH WATER SUPPLY FACILITIES MAP

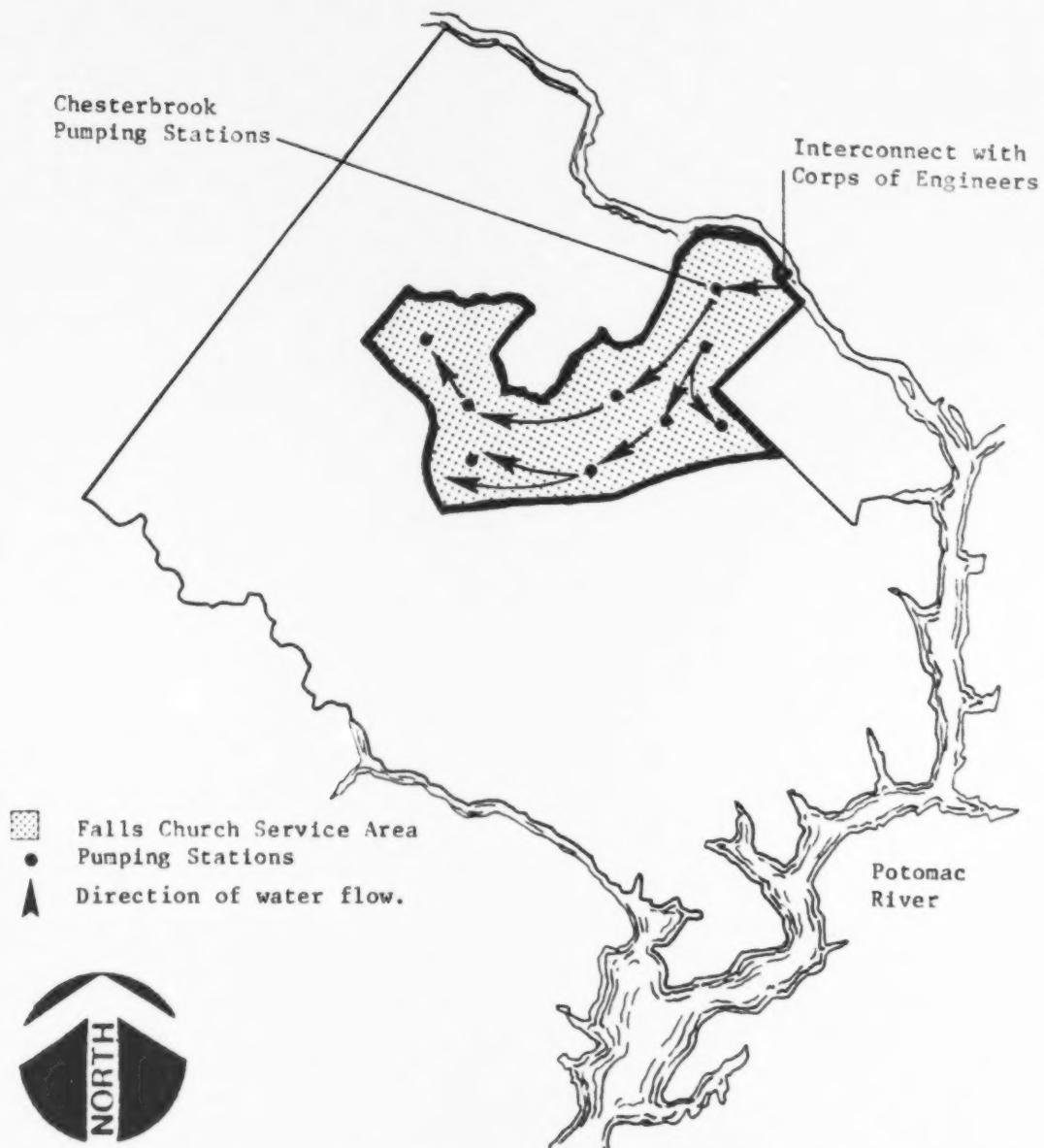


Figure E-13. Falls Church Water Supply service area map.

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square miles are in Fairfax County. An estimated population of 107,365 was served in 1976. The distribution system was acquired through the purchase of three private water companies, and supplemented by construction. In 1951, the City acquired the McLean Water Company, in 1962 the Tremont Water Company, and in 1963 the Boulevard Water Works, Inc.

Falls Church also has four wholesale customers: the Fairfax County Water Authority, the Town of Vienna, Arlington County, and an emergency connection with the City of Fairfax.

At the present time, Falls Church has 10 water storage tanks including reservoirs, standpipes, and elevated storage with a total capacity of 11.20 mil gal. The storage facilities are equipped with telemetering units which report the water level via tone systems to the central control office at the Chesterbrook pump station. Currently, there are plans for the erection of a one-mil-gal elevated tank. Table E-3 is a list of systems storage facilities.

There are nine pumping stations in the system with a total capacity of 27 MGD. Chesterbrook is the main station with living quarters provided for the pump station operator and his family. Each station can be operated automatically or manually from the station or from Chesterbrook. The information from the various stations is reported via telemetry. As of June 30, 1974, the system included 349.25 miles of mains.

COST ANALYSIS

Figure E-14 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

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Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment

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TABLE E-3. FALLS CHURCH WATER UTILITY SYSTEMS STORAGE

STORAGE FACILITY	ELEVATION (FEET ABOVE SEA LEVEL DATUM)	CAPACITY (MG)
7 Corners	464	1.50
Lewinsville	464	2.00
Falls Hill	464	1.00
Prout Hill	464	.60
Prout Hill #2	464	1.42
North Washington	464	.20
Tysons Corner	568	1.60
Poplar Heights	568	.68
Dunn Loring	568	2.00
Willston	568	.20

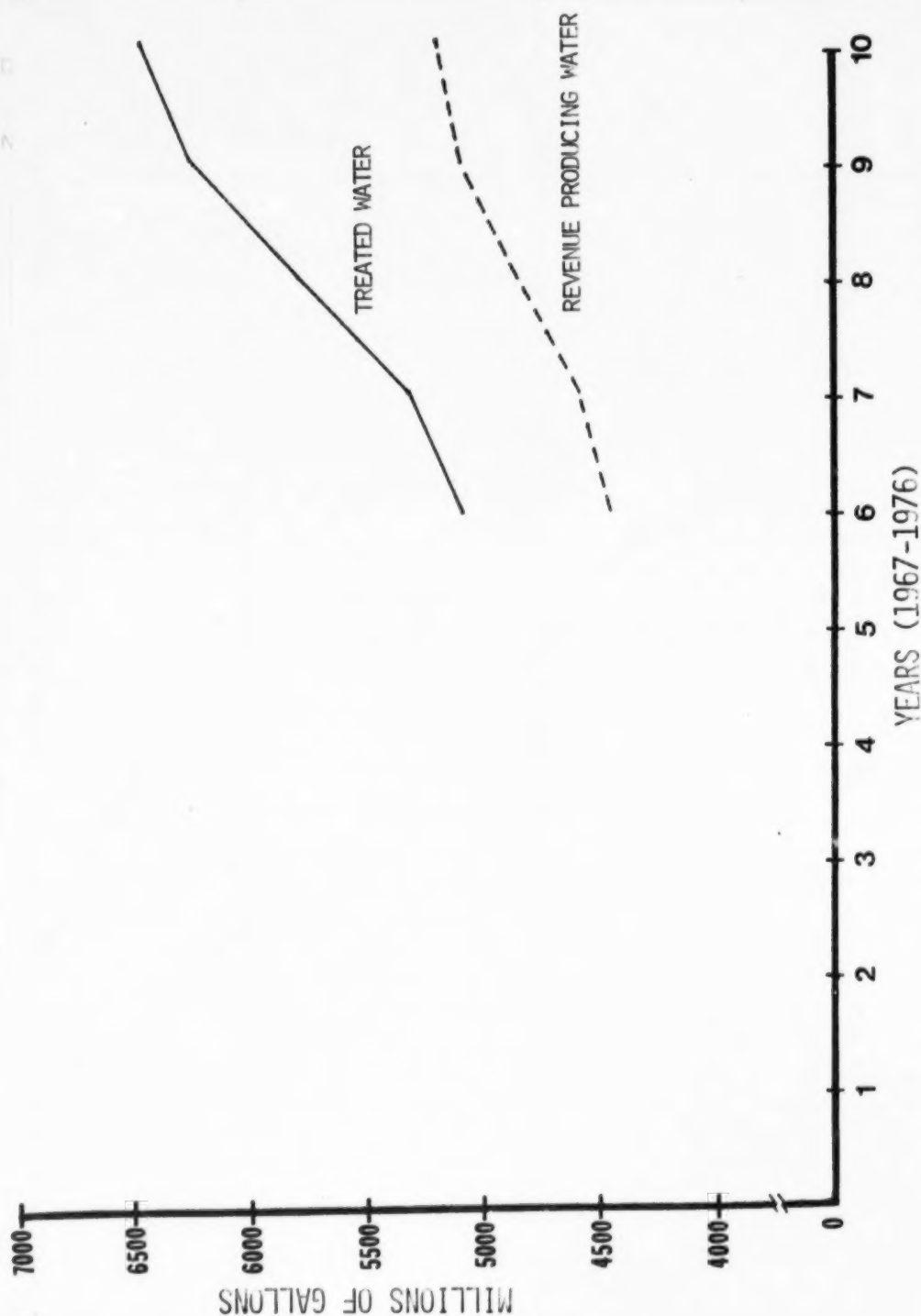
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FALLS CHURCH WATER UTILITY WATER FLOW: TREATED WATER vs RPW

Figure E-14. Falls Church Water Utility water flow: treated water vs RPW.

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information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

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SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-15 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Falls Church Water Supply is acquired at a cost of \$187.36/mil gal RPW. An additional \$148.05 is spent for distribution. Support services and interest costs are also added, yielding a total cost of \$487.96/mil gal of RPW.

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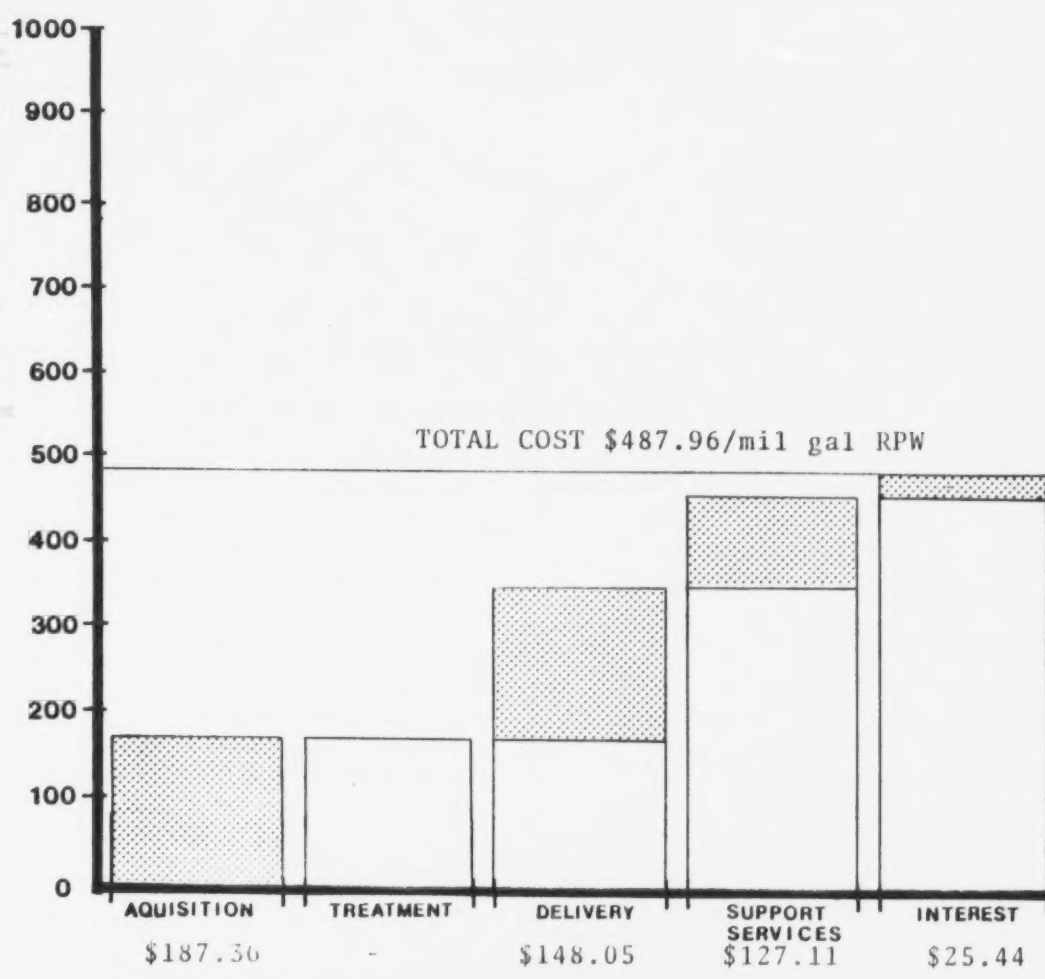


Figure E-15. Falls Church Water Supply allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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ARLINGTON COUNTY WATER SUPPLY

ORGANIZATION

The water system for Arlington County, Virginia, is owned and operated by the county government. The responsibilities are assumed by the Department of Utilities which is headed by a director who reports to the County Manager. There are four divisions in the Department of Utilities: 1) the Water-Sewer Division, responsible for water distribution, water and sewer engineering records, water main maintenance, and sewer main maintenance; 2) the Utilities Division responsible for billing and accounts, public contact, and physical control; 3) the Water Pollution Control Division responsible for the water pollution control plant and the sewer lift station; and 4) the Solid Waste Division responsible for refuse collection, street cleaning, leaf collections, and the refuse transfer station. The Department of Utilities had 317 authorized positions in 1976.

The Water-Sewer Division is responsible for providing an adequate and continuously operating water distribution system and sanitary sewer system. The division has 100 authorized positions and is divided into four operating sections. The Water Main Maintenance Section is responsible for maintenance and repair of water mains and installation of the service connections, including relocations and adjustments as necessary to insure an adequate water distribution system. The Sanitary Sewer Maintenance Section is responsible for the maintenance and repair of sanitary sewers and manholes, including relocations and adjustments as necessary to insure an adequate sanitary sewer system. In addition, this section performs concrete and masonry construction for all divisions of the department. The Water Distribution Section is responsible for the operation and maintenance of water meters, valves, pumping stations, storage facilities, and pressure regulating stations as necessary to insure an adequate supply of water at proper pressures for domestic use and fire protection. This section also operates the water distribution control center which provides for remote operation of pumping stations and continuously monitors pressures in the distribution system. The control center is a 24-hour-per-day operation and is responsible for receiving and dispatching emergency calls for the utilities and transportation department.

The Engineering Record Section is responsible for the planning, design, construction, inspection, and maintenance of records for the water distribution system and sanitary sewer system. In addition, this section provides for water sampling and testing, provides field investigation of

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water and sewer complaints, provides drafting services for all divisions of the department, and reviews plans for construction by other utilities and developers, and other state, city, and county agencies and departments.

The Utilities Service Division, also concerned with water supply, is responsible for meter reading, billing, and collection of the 33,000 water and sewer accounts and the billing of refuse charges for each single family residential dwelling and each unit of duplex residential dwellings. This division is also responsible for the billing and collecting of refuse hauling charges for each person having a permit to bring refuse to the transfer station in Arlington County. This division is the public contact for all services provided by the Department of Utilities. Administrative functions, such as fiscal control, budget administration, personnel management, and calls from the public regarding water, sewer, and solid waste disposal, are received and handled by this division. The division also prepares reports and correspondence for the Department of Utilities. Page 2 of the Arlington County system printout lists additional systems facts. Figure E-16 is a service area map of the Arlington system.

ACQUISITION-TREATMENT

Arlington County purchases 100 percent of its water from the Washington Aqueduct Division of the Corps of Engineers. All purchased water is treated at the Dalecarlia treatment facility.

DISTRIBUTION

The Arlington County distribution system consists of 428.5 miles of mains. Also included in the system are 2,744 fire hydrants. The county recently undertook a plan to increase elevated treated water storage to provide constant pressure and a reserve supply in case of shortages.

COST ANALYSIS

Figure E-17 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with

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ARLINGTON COUNTY WATER SUPPLY FACILITIES MAP

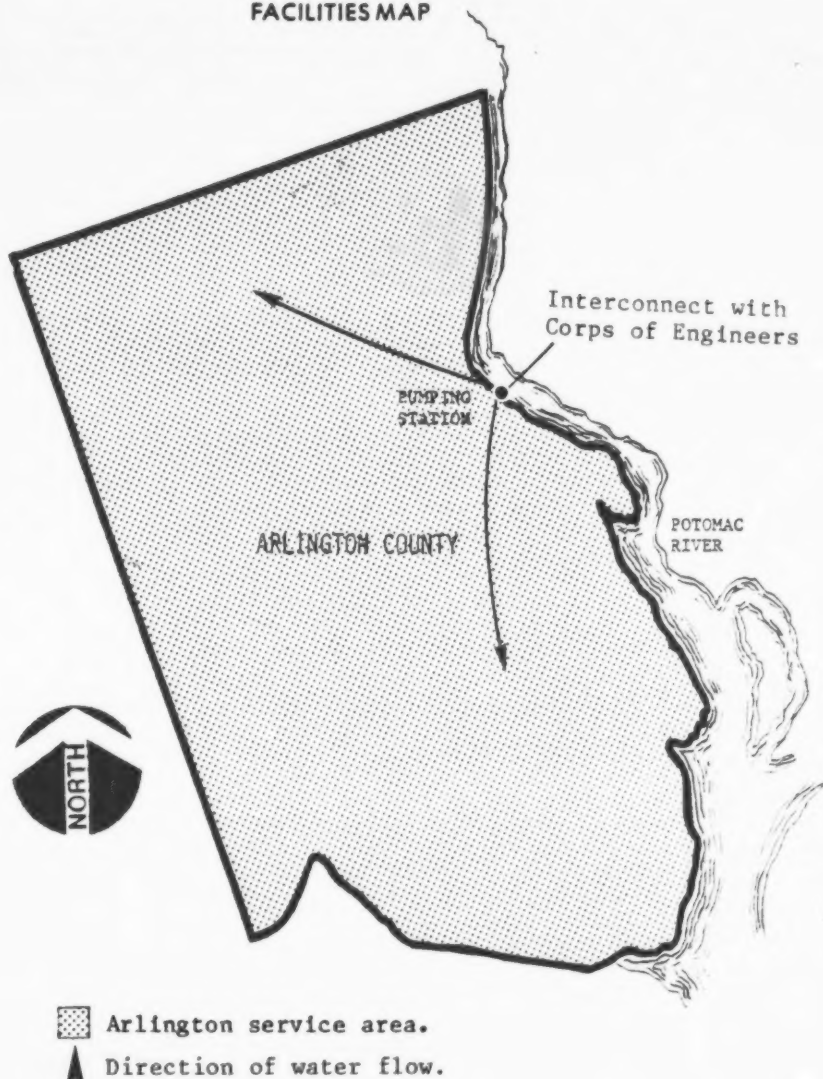


Figure E-16. Arlington County service area map.

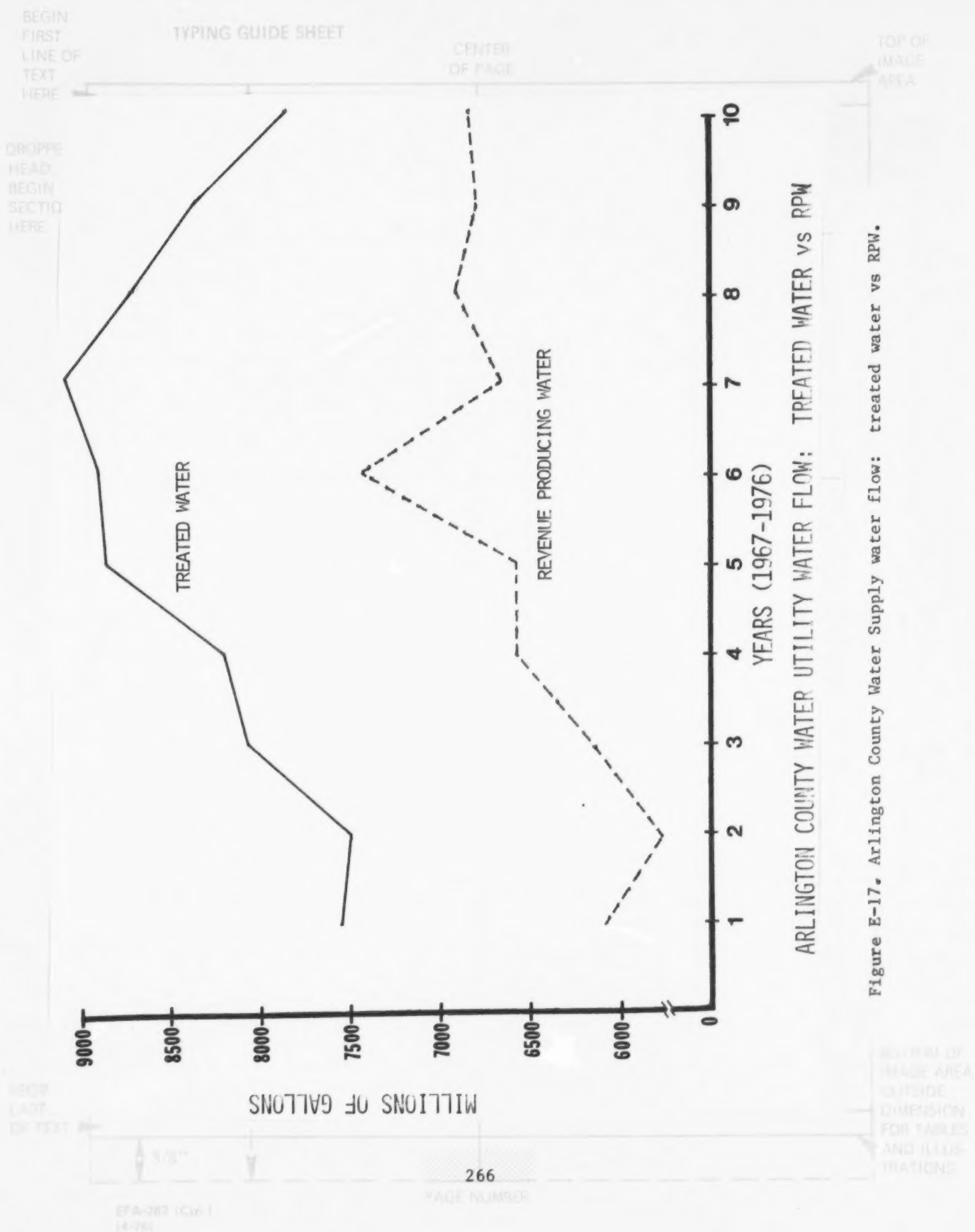


Figure E-17. Arlington County Water Supply water flow: treated water vs RPW.

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acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

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Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

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The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-18 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Arlington County Water Supply is acquired at a cost of \$156.98/mil gal RPW. An additional \$224.43 is spent for distribution. Support services and interest costs are also added, yielding a total cost of \$499.69/mil gal of RPW.

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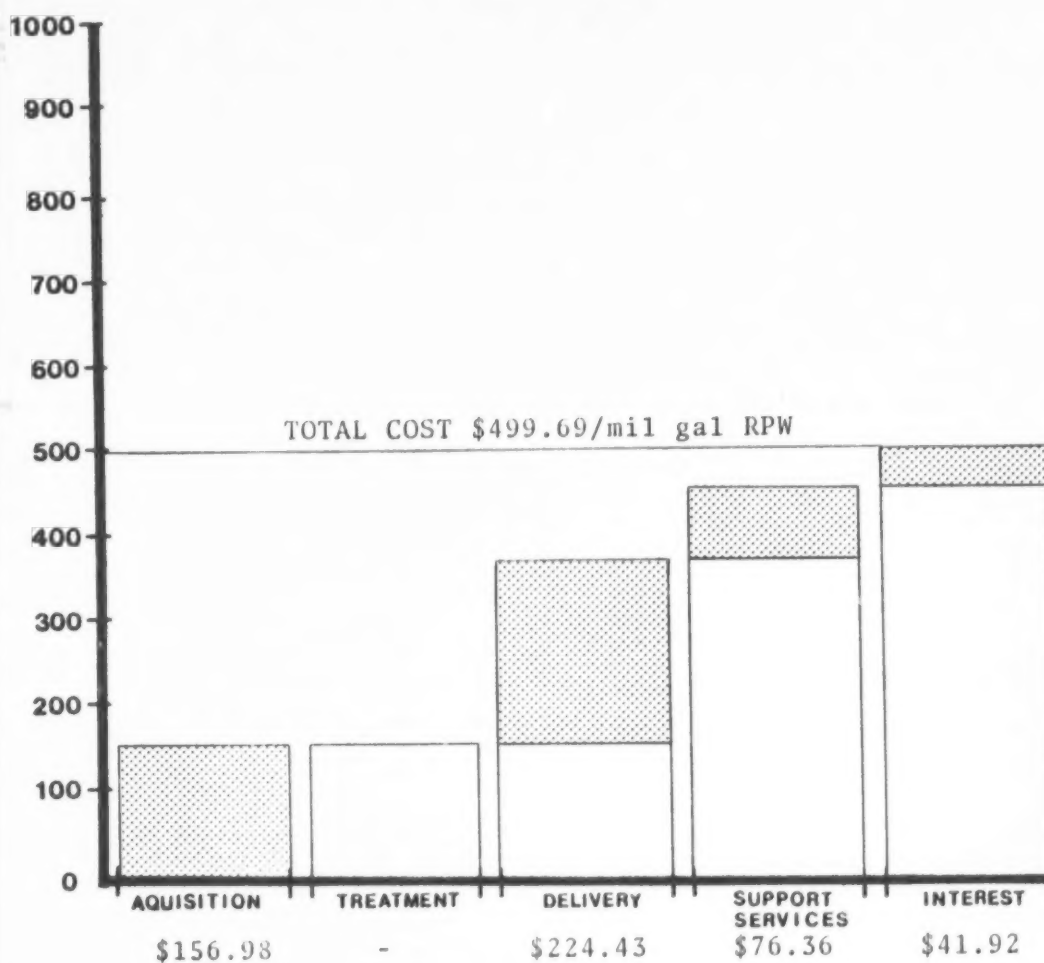


Figure E-18. Arlington Water Utility allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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LEESBURG WATER UTILITY

ACQUISITION-TREATMENT

The Town of Leesburg, Virginia, owns and operates the public water supply and distribution system. The source of supply consists of six drilled wells: Paxton, Phillips-Nichols, Meyers, Royals #1, Royals #2, and Firemen's. Page 2 of the Leesburg system printout lists additional systems facts. Figure E-19 is a service area map of the Leesburg Water Utility.

The Paxton well pumps directly into a 1.5-mil gal standpipe and into the distribution system. The standpipe is located west of Old Waterford Road near the hospital. Chlorination is provided at the well source. Chlorination is also provided at the Phillips-Nichols and Meyers well sites.

Royals #1 and #2 and Firemen's pump directly into a 90,000-gallon ground storage reservoir located near the town maintenance yard. The water pumped by these wells is chlorinated in an enclosed reservoir.

Some of the wells are caving in, and the Town of Leesburg has secured a permit to withdraw 3.5 MGD from the Potomac River. A treatment plant is in the planning stage to handle the surface water withdrawn from the river, and operation of the new system is possible four to five years away.

TRANSMISSION AND DISTRIBUTION

The distribution system of the Leesburg Water Utility consists of approximately 28.9 miles of 2- to 12-inch mains. In general, the older and smaller mains are located within the central portion of the town.

COST ANALYSIS

Figure E-20 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the

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LEESBURG WATER UTILITY FACILITIES MAP

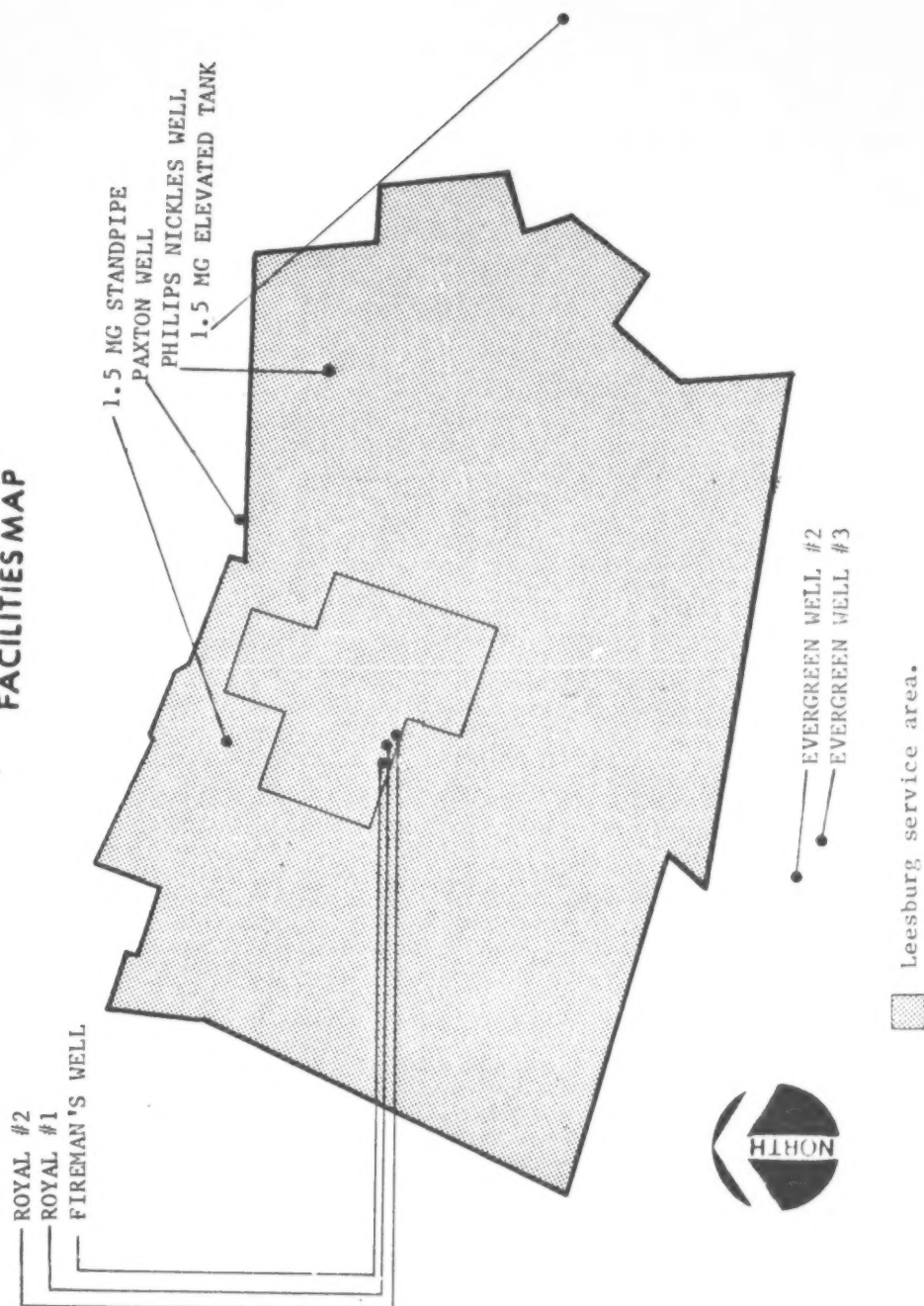


Figure E-19. Leesburg Water Utility service area map.



Figure E-20. Leesburg Water Utility water flow: treated water vs RPW.

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operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

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The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the bill consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

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THE 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

THE 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

EXAMINATION of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

TO analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-21 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

FOR example, water for the Leesburg Water Utility is acquired at a cost of \$149.86/mil gal RPW. An additional \$34.86 is spent on the treatment of the water, as is \$458.50 for distribution. Support services and interest costs are also added, yielding a total cost of \$908.50/mil gal of RPW.

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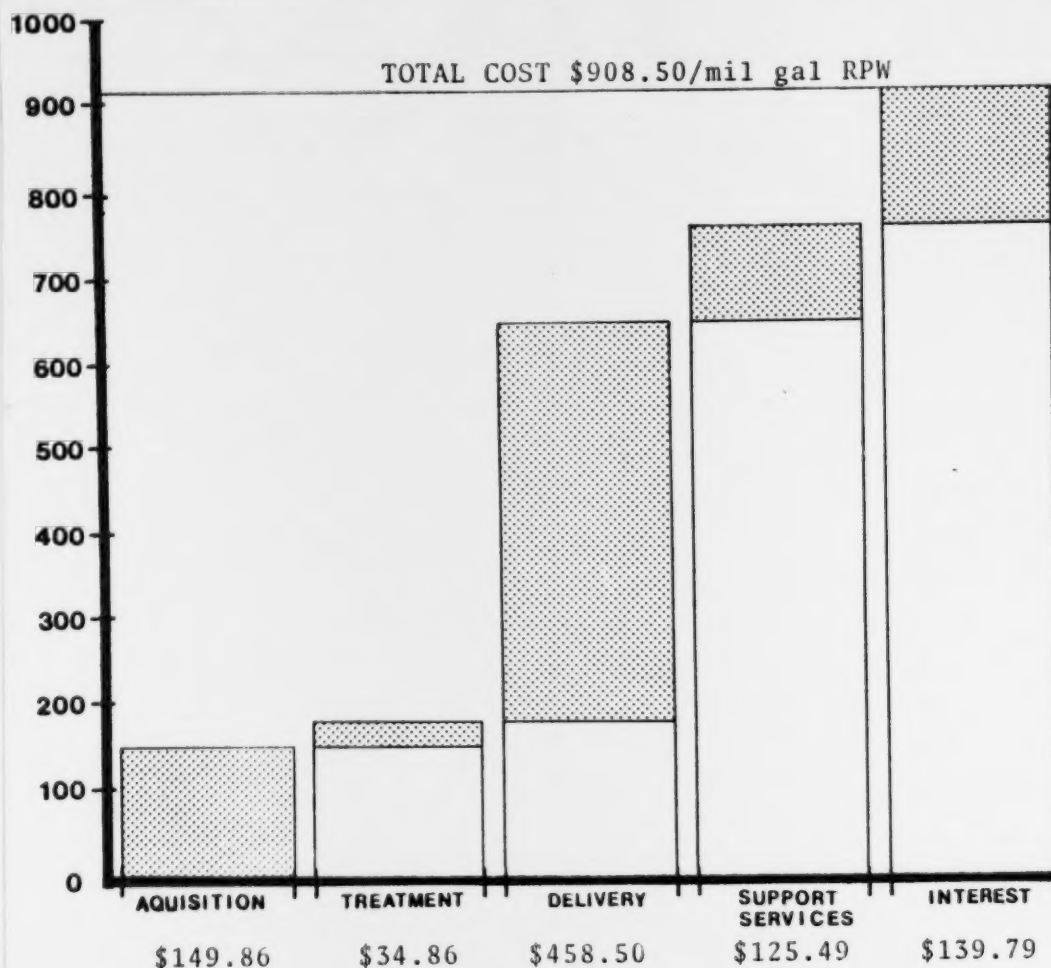


Figure E-21. Leesburg Water Utility allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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FAIRFAX COUNTY WATER AUTHORITY

The Fairfax County Water Authority, headquartered in Annandale, Virginia, was created under the Virginia Water and Sewage Authority Act of 1950 and was chartered by the State Corporation Commission on September 26, 1957 for the purpose of acquiring, constructing, operating, and maintaining an integrated water system to supply and distribute water to Fairfax County. The charter was amended in 1959 to add the provision for sewer systems and sewage disposal systems located within Fairfax County and partly within and without the county.

The Authority is a public body deemed to be an instrumentality exercising public and essential governmental functions to provide for the public health and welfare. The Authority is empowered to: 1) acquire, construct, operate, and maintain water supply systems; 2) finance its programs through the issuance of revenue bonds without obtaining referendum approval; and 3) fix and prescribe rates, fees, and charges for the services rendered. It cannot levy any taxes or assessments, nor do obligations of the Authority become obligations of Fairfax County.

Since 1959 the Authority has acquired 15 water companies, consisting of 22 separate water systems. The Alexandria Water Company, acquired in 1967, served 70 percent of the customers gained through the acquisitions.

The Fairfax County Water Authority serves approximately two-thirds of the population in Fairfax County and small areas in adjoining counties. The population is relatively stable, and little construction activity is taking place in the service area.

The retail service area encompasses approximately 400 square miles in Fairfax County. Water is supplied to some areas lying partly outside the county such as Dulles Airport. In addition to serving county residents, the Authority wholesales treated water to places such as Alexandria, Prince William Water Company, and other areas located in or near Fairfax County.

The service area is relatively level. The treatment plant is located on both banks of the Occoquan with primary treatment located on the south bank (approx. 50 feet above sea level), and secondary treatment across the creek at an elevation of approximately 260 feet above sea level.

This area is not expected to expand significantly in size unless an

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additional water system is acquired; however, the population of the present area is projected to increase the water demands at a rate of 3 to 4 percent per year through the year 1985. Page 2 of the Fairfax system printout lists additional systems facts. Figure E-22 is a service area map of the Fairfax system.

ORGANIZATION

The Authority is administered by a board of five members appointed by the County Board of Supervisors for staggered terms of three years each. Officers are elected by the members for a term of one year. Operations are accomplished by a director who reports to the five-member board.

The Director has four divisions reporting to him: 1) Engineering and Construction, responsible for designing and building facilities; 2) Finance, principally responsible for acquiring funds to support the operations; 3) Operations and Maintenance, responsible for accomplishing the production work and maintaining the equipment; and 4) General Services, responsible for performing support activities necessary to the operation of the utility.

Although the charter includes the right to provide sewage service, none is provided at the present time; therefore, it was not necessary to separate costs for water and sewage functions.

ACQUISITION

Raw water for the Fairfax County Water Authority comes from both surface and ground sources. Approximately 97 percent of the water used is surface water and 3 percent is groundwater.

The principal source of water is the Occoquan River which flows through Fairfax, Fauquier, Loudon, and Prince William Counties with an impounded watershed of approximately 570 square miles. Two dams, constructed near Occoquan, Virginia, impound the river for water supply. The lower dam, constructed in 1950, impounds a relatively small reservoir containing about 55 mil gal; and the upper dam, constructed approximately 3,000 feet upstream in 1957, impounds a reservoir containing about 9.8 billion gallons. As presently developed, the impounding water supply has a dependable yield of approximately 65 MGD even under the most severe drought conditions of record. Usually, during the months of November through April, the hydroelectric generating facilities utilize surplus stream flow to generate the power for pumping and treating water.

Supplementary sources of water include 26 wells and the purchase of water from Fort Belvoir and the cities of Fairfax and Falls Church. Provisions in the design and construction of the larger dam will permit a five-foot increase in height which will increase storage by about three billion gallons. The additional storage will increase the dependable yield to approximately 84 MGD. Easements have been obtained for flooding the additional acreage along the shoreline when the height of the dam is increased. The Fairfax County Water Authority is seeking a permit to draw

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FAIRFAX COUNTY WATER AUTHORITY FACILITIES MAP

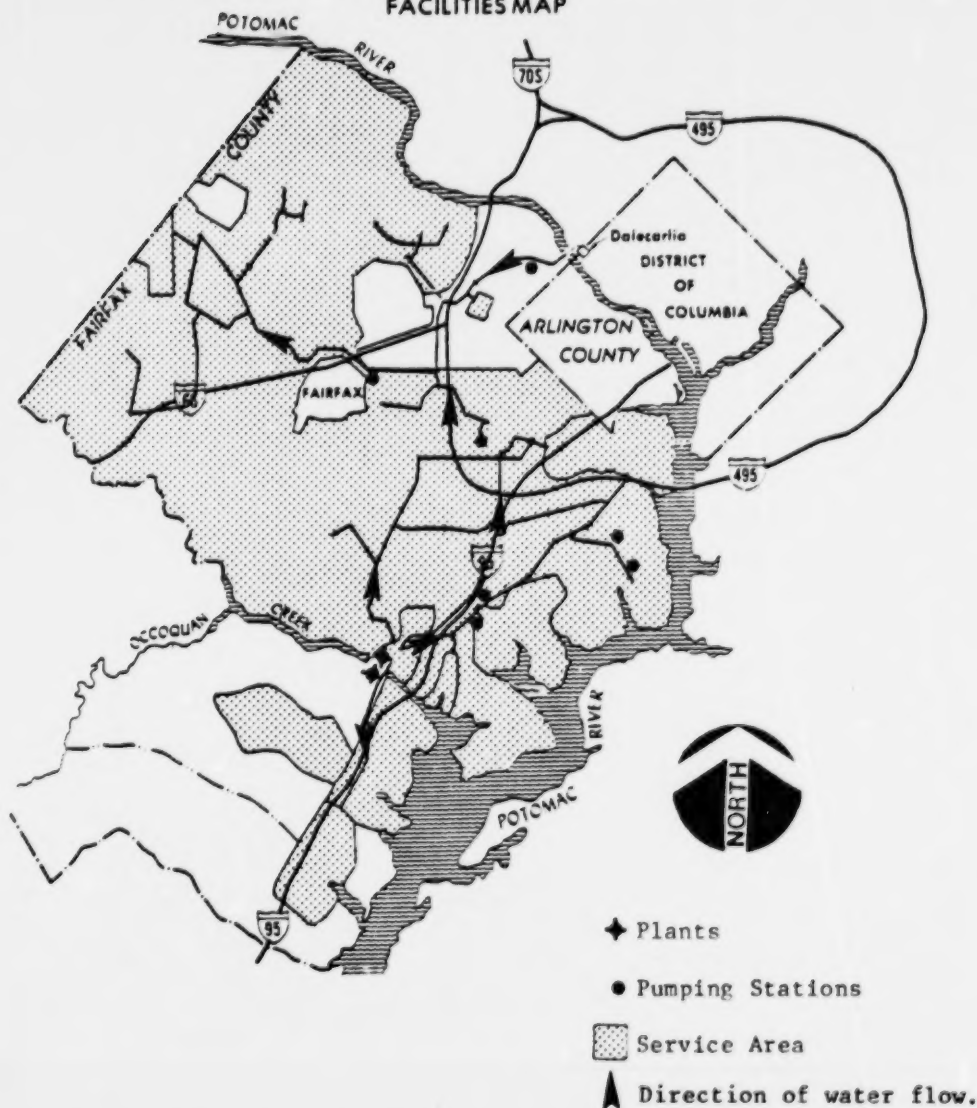


Figure E-22. Fairfax County Water Authority service area map.

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water from the Potomac River to supplement the present service to the northern part of the county.

TREATMENT

Water treatment is provided in two interconnecting plants constructed in stages during the period of 1950 to 1973. The combined maximum capacity of these facilities is 99.6 MGD.

The principal chemicals used in the treatment process include: 1) chlorine for disinfection, removal of manganese and iron, and control of taste and odor; 2) activated carbon for taste and odor control; 3) alum to assist in coagulation and settling of suspended materials; 4) lime to increase alkalinity for optimum coagulation and to inhibit pipe corrosion; 5) potassium permanganate for magnesium removal; 6) sodium bisulfate as a dechlorinating agent; and 7) fluoride for retardation of tooth decay. Four filtered water reservoirs, containing about 4.8 mil gal, are located at the treatment plant. Figure E-23 is a schematic of the system's treatment facilities.

TRANSMISSION AND DISTRIBUTION

The transmission and distribution system consists of approximately 1,400 miles of mains varying in diameter from 2 to 30 inches. Water is delivered into the transmission and distribution system by 18 pumping units providing a maximum capacity of 100 MGD. Operating pressures are maintained throughout the service area by 33 booster pumping stations with capacities ranging from 0.13 to 41 MGD.

A total of 17 mil gal water is stored in 44 reservoirs located within the service area, principally as follows: nine mil gal in three standpipes near Annandale, five mil gal in two standpipes at Gum Springs, two mil gal in two standpipes at Penderwood, and one mil gal in an elevated storage tank at Fairfax Hospital. Table E-4 lists system storage facilities.

The distribution system is interconnected at 64 locations with 12 other water systems in northern Virginia. Five of the systems have independent water supply sources, and seven are dependent on the Authority for their water supply.

In addition to its principal system, the Authority owns and operates seven independent well systems providing service to about 325 customers in communities distant from the principal system.

COST ANALYSIS

Figure E-24 illustrates the growth in consumer demand for water for the period of analysis. The two lines on the graph represent treated water or the amount of water flowing from the treatment facility and RPW, which is the amount of water sold by the utility.

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FAIRFAX COUNTY WATER AUTHORITY

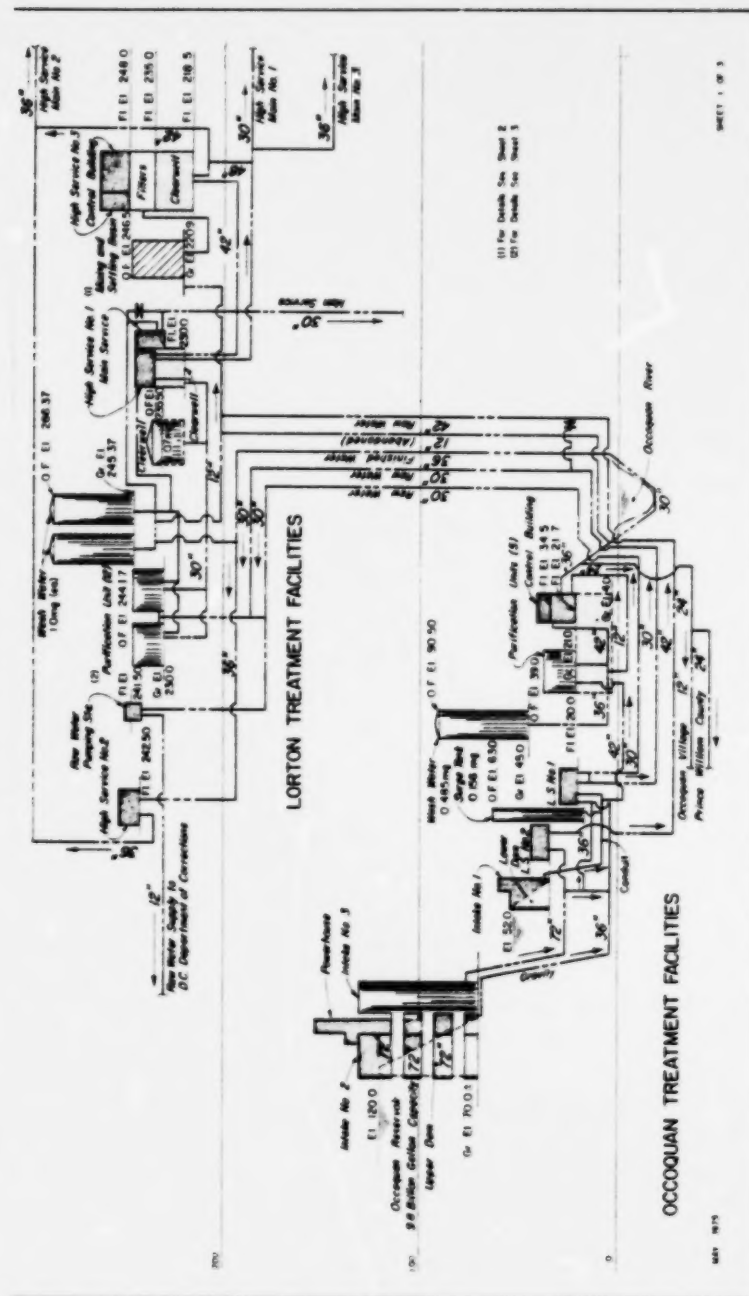


Figure E-23. Fairfax County Water Authority - treatment facilities diagram.

TABLE E-4. FAIRFAX COUNTY WATER AUTHORITY SYSTEMS STORAGE

STORAGE FACILITY	CAPACITY (MG)
Annandale	9
Gum Springs	5
Penderwood	2
Fairfax County Hospital	1

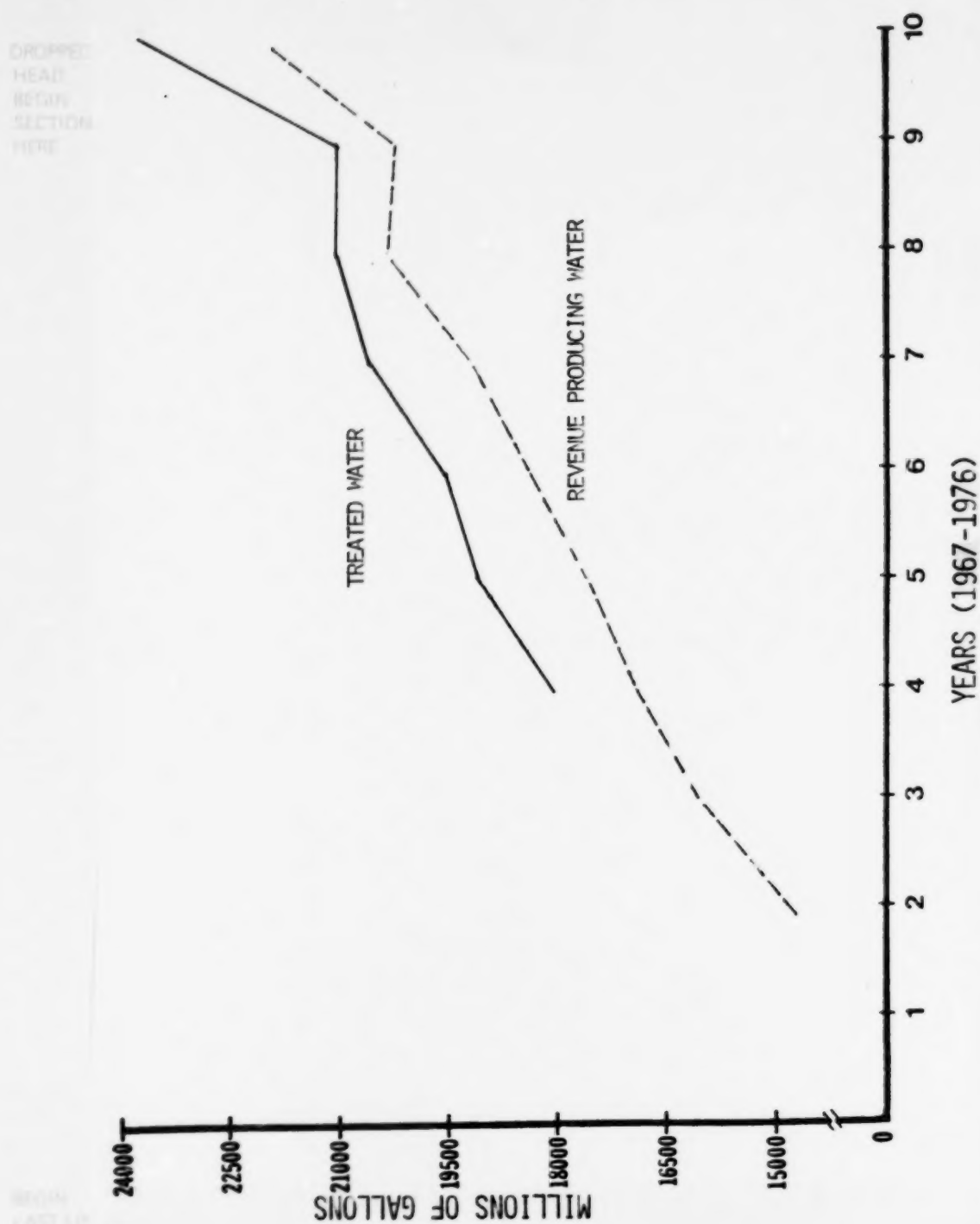


Figure E-24. Fairfax County Water Authority water flow: treated water vs RPW.

Operating and maintenance cost data were collected and reported using standard cost categories as shown on Page 4 of the printout. The key operating and maintenance cost analysis includes all costs identified in the utility records presented in three formats: cost per year is the total O&M cost per year in dollars, cost per million gallons (the operating and maintenance cost per year divided by RPW), and percent of total (the O&M cost per year as a percent of total cost per year).

The three formats are divided into four categories. Support services includes all costs which cannot be directly allocated to acquisition, treatment, and delivery of water, such as administrative cost, accounting, and collection, etc. Acquisition costs are all costs associated with acquiring water and transmitting it to the treatment facility. Treatment costs are all costs associated with purification. Delivery costs are all costs associated with storage, transmission, and distribution of water from the treatment facility to the customer.

Page 6 of the printout is the water treatment information report. This report provides information on water treatment processes that the utility is currently using along with associated cost. The treatment information is divided into three parts. The first, treatment processes, lists the types of treatment that are used by the utility. The second, treatment chemicals, identifies the chemicals used per mil gal of treated water during the last year. The third, 10-year chemical cost analysis, provides the total cost of chemicals used during each year for the past ten years, the amount of water that was treated, the billed consumption, the chemical cost in dollars per mil gal of treated water, and the chemical cost in dollars per mil gal of RPW.

Page 10 of the printout is a 10-year labor cost analysis for the water utility. The 10-year labor cost analysis includes the following information on an annual basis for the period of analysis: the payroll dollars, which are the O&M labor cost; the man-hours, which are total man-hours of work, if available; the mil gal billed consumption, which is RPW for the utility; the dollars per mil gal, which is the payroll divided by the RPW; the man-hours per mil gal, which is man-hours divided by the RPW; and the dollars per man-hour, which is payroll divided by man-hours.

A 10-year power cost analysis is illustrated on Page 12 of the printout. The 10-year power cost analysis includes the following information on an annual basis for the period of analysis: the power cost in total dollars per year; the kilowatt-hours used each year for the period of analysis, if available; the dollars per mil gal power cost, which is power cost divided by mil gal RPW; and kilowatt-hours per mil gal, which is the total kilowatt-hours used divided by mil gal RPW. Kilowatt-hours were not available for many of the Washington Metropolitan Area systems during the period of analysis.

The 10-year depreciation cost allocation may be found on Page 14 of the printout. The 10-year depreciation cost allocation report includes the following costs for the period of analysis. These costs are allocated

to the utility's functions of support services, acquisition, treatment, and distribution. Depreciation cost, included in the report, is the annual depreciation cost in dollars. Interest cost includes interest dollars or the total annual interest cost in dollars and interest cost per mil gal, which is the interest cost divided by mil gal of RPW.

The 10-year operating cost analysis, which may be found on Page 16 of the printout, provides a summary of capital and operating cost which has been presented on prior report pages, including O&M costs, depreciation costs, interest costs, total costs, total costs per mil gal, total costs in 1975 dollars, any special taxes that the utility may be paying, and O&M as a percent of total costs. All costs are provided for the period of analysis.

The 18th and final page of the cost analysis printout is a current year cost summary. The cost summary provides the support services, acquisition, treatment, distribution, interest, total taxes, and total cost with taxes of water on a dollar per mil gal RPW basis. The summary also provides these costs on a percent of subtotal and a percent of total basis.

SYSTEMS COST

Examination of the cost on a functional basis is only part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present costs in such a way that they relate to the delivery of water. The functional categories, both operating and capital, should, be reaggregated and assigned to functional elements of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the customer, it is necessary to identify the capital and operating costs of the system's components. Figure E-25 is a bar chart that shows combined operating and capital cost for each of the system's major functions. A linear assumption is made that allows cost per mil gal to be added to water as it moves from one functional cost center to the other.

For example, water for the Fairfax County Water Authority is acquired at a cost of \$33.72/mil gal RPW. An additional \$61.38 is spent on the treatment of the water, as is \$127.30 for distribution. Support services and interest costs are also added, yielding a total cost of \$570.30/mil gal of RPW.

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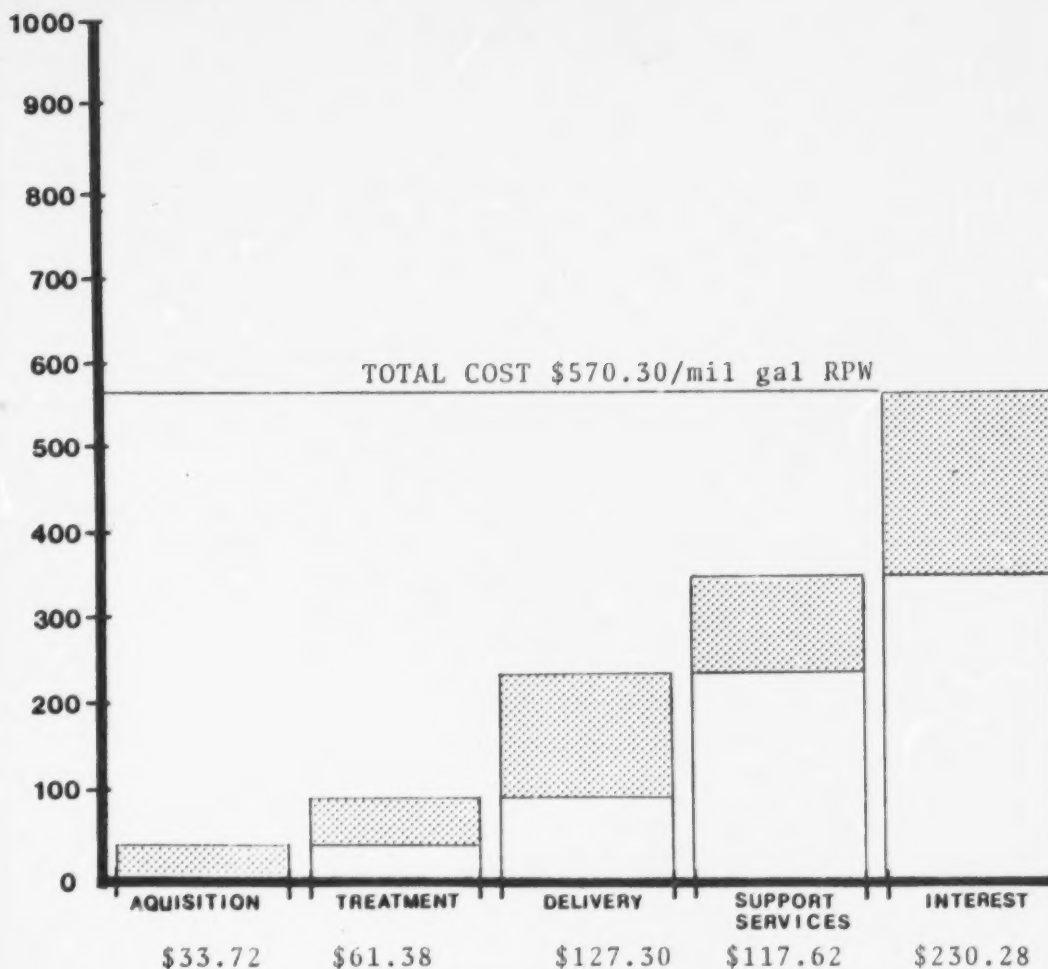


Figure E-25. Fairfax County Water Authority allocation of capital and operating expenses to water system functions (all costs in \$/mil gal RPW).

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COMPUTER PRINTOUT FOR WASHINGTON SUBURBAN SANITARY COMMISSION

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/10/77

UTILITY REPRESENTATIVE

Mr. Charles I. Sheetz
Asst Director Project Planning
WSSC

4017 Hamilton Street
Hayttsville, MD 20781
(301 277-7700

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SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
\$, MH, OR KWH/MILLION GALLONS TO \$, MH, OR KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

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SYSTEM FACTS
1976

POPULATION - SMSA	3371600
COUNTY	1388200
CITY OR TOWN	1300000.
RETAIL SERVICE AREA	1000.00 SQ MI
AREA OF RETAIL SERVICE AREA	231904.
NUMBER OF METERS	231904.
NUMBER OF ACCOUNTS	0.
NUMBER OF FLAT RATE ACCOUNTS	0 MG
PURCHASED WATER - RAW	0 MG
TREATED	0.0 %
SOURCE WATER - GROUND	100.0 %
SURFACE	3335 MI
PIPE IN SYSTEM	
ELEVATIONS - INTAKES	
TREATMENT PLANTS	
SERVICE AREA MIN.	
SERVICE AREA MAX.	
REVENUE PRODUCING WATER	42000.0000 MG
TREATED WATER	49094.0000 MG
MAX. DAY	196.62 MG
MAX. HOUR	N.A.
FISCAL YEAR	6/30
IMPLEMENTATION DATE	3/10/77
PROCESSING DATE	6/25/77

WSSC

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - OEM COST PER YEAR IN DOLLARS

COST/MG - OEM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OEM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

3-2-002
3/10/77

WSSC

10-YEAR KEY D C M COST ANALYSIS

.....
* 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 *
.....

COST/YEAR

SUPPORT SERVICES	500796.	577029.	698017.	718370.	818739.	836616.	900015.	1165294.	1425609.	1560676.
ACQUISITION	212982.	224584.	246303.	276198.	331680.	307143.	448545.	458638.	542964.	586975.
TREATMENT	1067452.	1191349.	1521169.	1720036.	1998413.	2164595.	2495725.	3138658.	4173983.	4547663.
DISTRIBUTION	2450206.	2791866.	2958680.	3661050.	4582424.	5182051.	6209767.	7236371.	9854575.	9333647.
TOTAL	4231436.	4784828.	5424169.	6375655.	7731256.	8490405.	10054052.	11998961.	15997131.	18028961.

CUST/MG

SUPPORT SERVICES	17.	19.	20.	20.	22.	22.	23.	29.	34.	37.
ACQUISITION	7.	7.	7.	8.	9.	8.	12.	11.	13.	14.
TREATMENT	36.	38.	43.	48.	53.	57.	64.	78.	99.	108.
DISTRIBUTION	82.	90.	85.	102.	121.	136.	159.	181.	235.	222.
TOTAL	141.	154.	155.	177.	203.	223.	258.	300.	361.	382.

% OF TOTAL

SUPPORT SERVICES	11.84	12.06	12.87	11.27	10.59	9.85	8.95	9.71	8.91	9.74
ACQUISITION	5.03	4.69	4.54	4.33	4.29	3.62	4.46	3.82	3.39	3.66
TREATMENT	25.23	24.90	28.04	26.98	25.85	25.49	24.82	26.16	26.09	28.37
DISTRIBUTION	57.90	58.35	54.55	57.42	59.27	61.03	61.76	60.31	61.60	58.23
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

WSSC
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSES, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS. THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-2-002
3/10/77

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TREATMENT INFORMATION

TREATMENT PROCESSES	100.0	TREATMENT CHEMICALS	LB/MG TREATED
COAGULATION	100.0		
FILTRATION	100.0		
CHLORINATION	100.0		
FLUORIDATION	100.0		
DECHLORINATION	100.0		

10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
TOTAL COST	224942.	266953.	324241.	400850.	451759.	427792.	370381.	379475.	722160.	752889.
TREATED WATER	35052.	36432.	41595.	42638.	45247.	44930.	46182.	47183.	49464.	49094.
BILLED MG	30000.	31000.	35000.	36000.	38000.	38000.	39000.	40000.	42000.	42000.
\$/MG TREATED	6.	7.	8.	9.	10.	10.	8.	8.	15.	15.
\$/MG BILLED	7.	9.	9.	11.	12.	11.	9.	9.	17.	18.

WSSC
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/LI)		PROPOSED SECONDARY STANDARD (MG/LI)	
-----		-----	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	ODOR	3 T.O.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FOAMING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
-----		-----	
TO 53.8	2.4	RADIUM 226	3 PCI/L
TO 58.3	2.2	GROSS BETA	1000 PCI/L
TO 63.8	2.0	GROSS ALPHA	15 PCI/L
TO 70.6	1.8	RADIUM 228	5 PCI/L
TO 79.2	1.6	STRONTIUM 90	8 PCI/L
TO 90.5	1.4	IODINE 131	2 PCI/L
ENDRIN	0.0002	TRITIUM	8 X 10E04/L
LINDANE	0.004		
PETHOXYCHLOR	0.1		
TOXAPHENE	0.005		
2,4-D	0.1		
2,4,5-TP	0.01		
TURBIDITY	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:
1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE ON SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

WSSC

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	MAX.	TEST	RAW	TREATED	TEST

WSSC

10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - GEM LABOR COST
MAN HOURS - TOTAL MAN HOURS WORKED
MG BILLED CONSUMPTION - REVENUE PRODUCING WATER
\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION
MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION
\$/MH - PAYROLL DIVIDED BY MAN HOURS

3-2-002
3/10/77

MSSC
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
PAYROLL \$	1463017.	1612828.	1741397.	2171516.	2209051.	2832563.	3269474.	2608004.	4686640.	4694220.	
MAN HOURS	--	--	--	--	--	--	--	--	--	--	
MC BILLED CONSUMPTION	30000.	31000.	35000.	36000.	38000.	38000.	39000.	40000.	42000.	42000.	
\$/MC	49.	52.	50.	60.	60.	75.	84.	67.	112.	112.	
MT/MC	--	--	--	--	--	--	--	--	--	--	
\$/MH	--	--	--	--	--	--	--	--	--	--	

WSSC

10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

3-2-002

3/10/77

WSSC

10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	614949.	669771.	812749.	865810.	1058794.	1023745.	1185743.	1730838.	2261058.	2441222.
KWH	--	--	--	--	--	--	--	--	--	--
\$/MG	20.	22.	23.	24.	28.	27.	30.	43.	54.	58.
KWH/MG	--	--	--	--	--	--	--	--	--	--

WSSC

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION
GALLONS BILLED CONSUMPTION)

3-2-002
3/10/77

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10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
DEPRECIATION COST \$										

SUPPORT SERVICES	156077.	126523.	212793.	108297.	66846.	151884.	135034.	135270.	138760.	261973.
ACQUISITION	36021.	36021.	36021.	36021.	36021.	36021.	36021.	36021.	36021.	36021.
TREATMENT	228081.	294138.	307440.	307493.	486101.	544919.	545883.	557913.	558510.	574320.
DISTRIBUTION	445806.	584425.	692258.	928581.	996264.	1029497.	1045531.	1063655.	1138889.	1139994.
TOTAL	865985.	1041107.	1248512.	1380392.	1585232.	1762321.	1762469.	1792859.	1872200.	2012308.

DEPRECIATION COST \$/MG

SUPPORT SERVICES	5.	4.	6.	3.	2.	4.	3.	3.	3.	6.
ACQUISITION	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
TREATMENT	8.	9.	9.	9.	13.	14.	14.	14.	13.	14.
DISTRIBUTION	15.	19.	20.	26.	26.	27.	27.	27.	27.	27.
TOTAL	29.	34.	36.	38.	42.	46.	45.	45.	45.	48.

DEPRECIATION COST % OF TOTAL

SUPPORT SERVICES	18.02	12.15	17.04	7.85	4.22	8.62	7.66	7.54	7.41	13.02
ACQUISITION	4.16	3.46	2.89	2.61	2.27	2.04	2.04	2.01	1.92	1.79
TREATMENT	26.34	28.25	24.62	22.28	30.66	30.92	30.97	31.12	29.83	28.54
DISTRIBUTION	51.48	56.13	55.45	67.27	62.85	58.42	59.32	59.33	60.83	56.65
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

INTEREST COST \$

INTEREST \$	1723713.	2334849.	2899412.	3478153.	4270898.	4719338.	4623382.	4933255.	5631384.	5725517.
INTEREST \$/MG	57.	75.	83.	97.	112.	124.	119.	123.	134.	136.

WSSC

10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

DEM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

DEM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

3-2-002
3/10/77

WSSC

10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
U E M	4231436.	4784828.	5424169.	6375655.	7731256.	8490405.	10054052.	11998961.	15997131.	16028961.	
DEPRECIATION	865985.	1041107.	1248512.	1380392.	1585232.	1762321.	1762469.	1792859.	1872200.	2012308.	
INTEREST	1723713.	2334849.	2899412.	3478153.	4270898.	4719338.	4623382.	4933255.	5631384.	5725517.	
TOTAL	6821134.	8160784.	9572093.	11234200.	13587386.	14972064.	16439903.	18725075.	23500715.	23766786.	
\$/MG	227.	263.	273.	312.	358.	394.	422.	468.	560.	566.	
\$/MG 1975 DOLLARS	366.	408.	402.	434.	476.	508.	510.	510.	560.	515.	
SPECIAL TAXES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
U E M & OF TOTAL	62.03	58.63	56.67	56.75	56.90	56.71	61.16	64.08	68.07	67.44	

PAGE 16

WSSC
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

3-2-002
3/10/77

WSSC

COST SUMMARY FOR 1976

***** *SUPPORT SERVICES* ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX * *****						
\$/MG	43.	15.	122.	249.	136.	566.
% OF TOTAL	7.67	2.62	21.55	44.07	24.09	100.00
% OF TOTAL W/TAX	7.67	2.62	21.55	44.07	24.09	100.00
					0.00	100.00

IN SUMMARY:

DURING THE PAST 10 YEARS, \$ 176133952. TOTAL COST IN 1975 DOLLARS PRODUCED
371000. MG WATER FOR AN AVERAGE COST OF \$ 475./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR PUBLIC WATER SYSTEM OF THE DISTRICT OF COLUMBIA

(This printout combines the Aqueduct Division of the Corps of
Engineers and elements of the D.C. Department of Environmental Services.)

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/10/77

COE REPRESENTATIVE

Mr. Harry Ways
Chief
Washington Aqueduct
5900 McArthur Blvd N.W.
Washington, D.C. 20315

D.C.- DES REPRESENTATIVE

Mr. Mario J. Aiello
Chief, Budget Branch
D.C. DES
415 12th Street, N.W.
Washington, D.C. 20004

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3-9-7000
3/15/77

PAGE 1

D.C. WATER SYSTEM SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
MG, MH, OR KWH/MILLION GALLONS TO \$, MH, OR KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

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3/15/77

PAGE 3

D.C. WATER SYSTEM

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - OCM COST PER YEAR IN DOLLARS

COST/MG - OCM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OCM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

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ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

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1/15/77

D.C. WATER SYSTEM
SYSTEM FACTS
1976

POPULATION - SMSA	830000
COUNTY	750000.
CITY OR TOWN	75.00 SQ MI
RETAIL SERVICE AREA	127000.
AREA OF RETAIL SERVICE AREA	127000.
NUMBER OF METERS	0.
NUMBER OF ACCOUNTS	0 MG
NUMBER OF FLAT RATE ACCOUNTS	0 MG
PURCHASED WATER - RAW	0.0 %
TREATED	100.0 %
SOURCE WATER - GROUND	1400 MI
SURFACE	--
PIPE IN SYSTEM	--
ELEVATIONS - INTAKES	90 FT
TREATMENT PLANTS	420 FT
SERVICE AREA MIN.	55355.0000 MG
SERVICE AREA MAX.	72244.0000 MG
REVENUE PRODUCING WATER	
TREATED WATER	
MAX. DAY	
MAX. HOUR	
FISCAL YEAR	6/30
IMPLEMENTATION DATE	3/15/77
PROCESSING DATE	3/27/79

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3/15/77

D.C. WATER SYSTEM

10-YEAR RCV N E M COST ANALYSIS

.....
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....

COST/YEAR

SUPPORT SERVICES	2591500.	2749800.	2903900.	3149500.	3509300.	3739400.	4124500.	4077300.	4368300.	4101400.
ACQUISITION	202900.	191300.	165000.	158100.	254100.	264800.	313500.	350300.	391200.	379900.
TREATMENT	1333400.	1417800.	1501700.	1814700.	1964300.	2119300.	2320800.	2367200.	3065300.	3521800.
DISTRIBUTION	3702300.	3937400.	4404300.	4748900.	4938700.	5010100.	5012000.	5681700.	6099100.	6489700.
TOTAL	7830100.	8266300.	8954900.	9871200.	10664400.	11133600.	11770800.	12476500.	13923900.	14692800.

COST/MG

SUPPORT SERVICES	46.	48.	48.	52.	55.	58.	66.	65.	71.	74.
ACQUISITION	4.	3.	3.	3.	4.	4.	5.	6.	6.	7.
TREATMENT	74.	25.	25.	30.	31.	33.	37.	37.	50.	64.
DISTRIBUTION	66.	69.	73.	78.	77.	78.	80.	90.	100.	117.
TOTAL	140.	145.	148.	162.	166.	174.	188.	197.	228.	262.

% OF TOTAL

SUPPORT SERVICES	33.10	33.14	32.20	31.91	32.90	33.59	35.04	32.68	31.37	28.30
ACQUISITION	2.59	2.31	1.84	1.60	2.38	2.38	2.66	2.81	2.81	2.62
TREATMENT	17.03	17.09	16.77	18.38	18.42	19.04	19.72	18.97	22.01	24.19
DISTRIBUTION	47.28	47.46	49.18	48.11	46.30	45.00	42.58	45.54	43.80	44.78
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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3-D-000
3/15/77

PAGE 5

D.C. WATER SYSTEM
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY. THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR. THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

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3/15/77

D.C. WATER SYSTEM

THE FAYMENT INFIRMARY

..... TREATMENT PROCESSES & WATER TREATU
..... TREATMENT CHEMICALS & LAUNG TREFU
.....

10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
TOTAL COST	397413.	388631.	453264.	569443.	542036.	570492.	610931.	740229.	1038031.	1077116.
IRRIATED WATER	65946.	67527.	70988.	70484.	73011.	74322.	74171.	74583.	70338.	72246.
BILLED MG	56054.	57397.	60362.	61084.	64353.	64112.	62516.	63175.	61169.	55355.
\$/MG TREATED	6.	6.	6.	8.	7.	8.	8.	10.	15.	15.
\$/MG RILLED	7.	7.	8.	9.	8.	9.	10.	12.	17.	19.

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3/15/77

PAGE 7

D.C. WATER SYSTEM
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)		PROPOSED SECONDARY STANDARD (MG/L)	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	COPPER	3 I.U.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FUAMING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
NITRATE	0.01	SULPHATE	250.
SELENIUM	0.05	ZINC	5.
SILVER			
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
TO 53.8	2.4	RADIUM 226	3 PCI/L
TO 58.3	2.2	GROSS BETA	1000 PCI/L
TO 63.8	2.0	GROSS ALPHA	15 PCI/L
TO 70.6	1.8	RADIUM 228	5 PCI/L
TO 79.2	1.6	STRONTIUM 90	8 PCI/L
TO 90.5	1.4	IODINE 131	2 PCI/L
ENDRIN	0.0002	TRITIUM	8 x 10 ⁶ d/L
LINDANE	0.004		
METHOXYCHLOR	0.1		
TOXAPHENE	0.005		
2,4-D	0.1		
2,4,5-TP	0.01		
TURBIDITY	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:
1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

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RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

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PAGE 9

D.C. WATER SYSTEM

10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - DEM LABOR COST

MAN HOURS - TOTAL MAN HOURS WORKED

MG BILLED CONSUMPTION - REVENUE PRODUCING WATER

\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION

HH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION

\$/HH - PAYROLL DIVIDED BY MAN HOURS

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D.C. WATER SYSTEM
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	*
PAYROLL \$	--	--	--	--	--	--	--	--	--	--	--
MAN HOURS	--	--	--	--	--	--	--	--	--	--	--
MG RILLED CONSUMPTION	56054.	57397.	60362.	61084.	64353.	64112.	62514.	63175.	61169.	55355.	
\$/MG	--	--	--	--	--	--	--	--	--	--	--
MH/MG	--	--	--	--	--	--	--	--	--	--	--
\$/MH	--	--	--	--	--	--	--	--	--	--	--

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3/15/77

PAGE 11

D.C. WATER SYSTEM

10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN
ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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N.C. WATER SYSTEM 10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	603900.	597100.	680600.	755400.	869600.	845000.	963100.	1325000.	1772100.	1762900.
KWH	--	--	--	--	--	--	--	--	--	--
\$/MG	11.	10.	11.	12.	14.	13.	15.	21.	29.	25.
KWH/MG	--	--	--	--	--	--	--	--	--	--

PAGE 17

3-0-000
3/15/77

D.C. WATER SYSTEM
10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION)

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N.C. WATER SYSTEM
10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
SUPPORT SERVICES	673430.	673600.	686600.	699600.	706000.	707600.	716200.	716200.	732600.	755800.
ACQUISITION	235700.	235760.	240310.	244860.	247100.	247660.	250670.	250670.	256410.	266530.
TREATMENT	606087.	606250.	617960.	629640.	635400.	636860.	644580.	644580.	659340.	680220.
DISTRIBUTION	1851932.	1852600.	1868150.	1923900.	1941500.	1945900.	1969550.	1969550.	2014650.	2078450.
TOTAL	3367169.	3368000.	3433000.	3498000.	3530000.	3538000.	3581000.	3581000.	3663000.	3779000.

DEPRECIATION COST \$/MG

SUPPORT SERVICES	12.	12.	11.	11.	11.	11.	11.	11.	12.	14.
ACQUISITION	4.	4.	4.	4.	4.	4.	4.	4.	4.	5.
TREATMENT	11.	11.	10.	10.	10.	10.	10.	10.	11.	12.
DISTRIBUTION	33.	32.	31.	31.	30.	30.	32.	31.	33.	39.
TOTAL	60.	59.	57.	57.	55.	55.	57.	57.	60.	69.

DEPRECIATION COST \$ OF TOTAL

SUPPORT SERVICES	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.37
ACQUISITION	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
TREATMENT	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.30
DISTRIBUTION	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.37
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.37

INTEREST COST \$

INTEREST \$	769863.	820000.	787459.	800071.	774244.	1043681.	1121077.	1210077.	1326043.	1518060.
INTEREST \$/MG	16.	16.	13.	13.	12.	16.	18.	19.	22.	27.

PAGE 16

3-0-000
3/15/77

D.C. WATER SYSTEM
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

- DEM - OPERATING AND MAINTENANCE COSTS
- DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE METHOD)
- INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT
- TOTAL - SUM OF THE ABOVE COSTS
- \$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION
- \$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER PRICE INDEX
- SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)
- DEM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

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N.C. WATER SYSTEM
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
DEPRECIATION	7930100.	8296300.	8954900.	9871200.	10666400.	11133600.	11770800.	12476500.	13223900.	14692800.
INTEREST	3467149.	3468000.	3433000.	3498000.	3530000.	3538000.	3581000.	3663000.	3779000.	3910000.
TOTAL	769863.	820080.	767439.	800031.	716244.	1060681.	1121077.	1210077.	1326063.	1518063.
PERCENTAGE	11967112.	12484380.	13178339.	146169231.	14970644.	15712881.	1647877.	17267577.	18912963.	19789863.
PERCENT	213.	218.	218.	232.	233.	265.	266.	273.	309.	358.
PERCENT	364.	337.	321.	322.	309.	316.	319.	298.	303.	325.
PERCENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	65.43	66.45	67.97	69.67	71.25	70.86	71.46	72.24	73.62	73.23

PAGE 16

3-9-000
3/15/77

PAGE 17

D.C. WATER SYSTEM
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

D.C. WATER SYSTEM
COST SUMMARY FOR 1976

COST SUMMARY FOR 1976

=====

* SUPPORT SERVICES ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX *

=====

\$/MG.	RB.	12.	76.	155.	27.	358.	0.	358.
3.26	24.54	3.26	21.23	43.30	7.67	100.00		
3.26	24.54	3.26	21.23	43.30	7.67	100.00	0.00	100.00
3.26	24.54	3.26	21.23	43.30	7.67	100.00	0.00	100.00

IN SUMMARY

605575. HC WATER FOR AN AVERAGE COST OF \$ 320./MG. (1975 DOLLARS)

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COMPUTER PRINTOUT FOR THE WASHINGTON AQUEDUCT DIVISION
U.S. ARMY CORPS OF ENGINEERS

(This printout represents cost from the Aqueduct Division of the Corps of Engineers as a separate utility. RPW figures represent water pumped from treatment plants.)

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/10/77

UTILITY REPRESENTATIVE

Mr. Harry Ways
Chief
Washington Aqueduct Division
U.S. Army Corps of Engineers
5900 McArthur Blvd. N.W.
Washington, D.C. 20315
(202) 282-2755

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PAGE 1

WASHINGTON AQUEDUCT
SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR	MULTIPLY BY 0.12
PARTS PER MILLION	
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
\$. MH, OR KWH/MILLION GALLONS TO \$, MH, OR	MULTIPLY BY 0.26
KWH/THOUSAND CUBIC METERS	
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

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PAGE 2

WASHINGTON AQUEDUCT SYSTEM FACTS 1976

POPULATION - SMSA	320000
COUNTY	NONE
CITY OR TOWN	746000
RETAIL SERVICE AREA	3.
AREA OF RETAIL SERVICE AREA	0.00 SQ MI
NUMBER OF METERS	2.
NUMBER OF ACCOUNTS	3.
NUMBER OF FLAT RATE ACCOUNTS	1.
PURCHASED WATER - RAW	30 MG
TREATED	30 MG
SOURCE WATER - GROUND	3.0 %
SURFACE	103.0 %
PIPE IN SYSTEM	90 MI
ELEVATIONS - INTAKES	141 FT
TREATMENT PLANTS	
SERVICE AREA MIN.	
SERVICE AREA MAX.	
REVENUE PRODUCING WATER	72246.0000 MG
TREATED WATER	72246.0000 MG
MAX. DAY	254.6 MG
MAX. HOUR	
FISCAL YEAR	6/30
IMPLEMENTATION DATE	3/30/77
PROCESSING DATE	4/ 4/77

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PAGE 3

WASHINGTON AQUEDUCT

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - DLM COST PER YEAR IN DOLLARS

COST/MG - DLM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - DCM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

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WASHINGTON AQUEDUCT
10-YEAR KEY D C M COST ANALYSIS

1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
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COST/YEAR

SUPPORT SERVICES	1299030.	1430261.	1519375.	1566346.	1651098.	1750559.	1849672.	1933182.	2195426.	2126895.
ACQUISITION	202896.	191343.	165030.	156125.	254086.	264790.	313530.	350275.	391208.	379937.
TREATMENT	1333373.	1417790.	1501731.	1814710.	1964317.	2119374.	2320755.	2367184.	3065262.	3521823.
DISTRIBUTION	479253.	523788.	577591.	600212.	750247.	768873.	767808.	1338962.	1338645.	1391634.
TOTAL	3314553.	3563182.	3763728.	4139393.	4619749.	4903527.	5251766.	5649604.	6991541.	7620262.

COST/MG

SUPPORT SERVICES	20.	21.	21.	22.	23.	24.	25.	25.	31.	23.
ACQUISITION	3.	3.	2.	2.	3.	4.	4.	5.	6.	5.
TREATMENT	20.	21.	21.	26.	27.	29.	31.	32.	44.	49.
DISTRIBUTION	7.	8.	8.	9.	10.	10.	10.	14.	19.	19.
TOTAL	50.	53.	53.	59.	63.	66.	71.	76.	99.	103.

% OF TOTAL

SUPPORT SERVICES	39.19	40.14	40.37	37.84	35.74	35.70	35.22	33.51	31.42	28.56
ACQUISITION	6.12	5.37	4.38	3.82	5.50	5.40	5.97	6.20	5.67	5.12
TREATMENT	40.23	39.79	39.90	43.84	42.52	43.22	44.19	41.30	43.84	47.46
DISTRIBUTION	14.46	14.70	15.35	14.50	16.24	15.68	14.62	18.39	19.15	18.75
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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WASHINGTON AQUEDUCT TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

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WASHINGTON AQUEDUCT

TREATMENT INFORMATION

TREATMENT PROCESSES	% WATER TREATED	TREATMENT CHEMICALS	LB/MG TREATED
SEDIMENTATION	100.2	CHLORINE	58.5
COAGULATION	100.2	LIME	92.5
FILTRATION	100.2	AL SULFATE	174.4
CHLORINATION	100.2	M2SIF6	40.5
FLOCCULATION	100.2		

10-YEAR CHEMICAL COST ANALYSIS

TOTAL COST	397413.	388631.	453264.	569443.	542036.	570492.	610931.	740229.	1038031.	1077114.
TREATED WATER	65946.	67527.	70988.	70484.	73011.	74322.	74171.	74583.	70339.	72246.
BILLED MG	65946.	67527.	70988.	70484.	73011.	74322.	74171.	74583.	70339.	72246.
\$/MG TREATED	6.	6.	6.	8.	7.	8.	8.	10.	15.	15.
\$/MG BILLED	6.	6.	6.	8.	7.	9.	8.	10.	15.	15.

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WASHINGTON AQUEDUCT RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

PROPOSED SECONDARY STANDARD (MG/L)

COLOR 15 UNITS
ODOR 3 I.O.N.
CHLORIDE 250.
COPPER 0.2
FOAMING AGENTS 0.05
IRON 0.3
MANGANESE 0.05
SULPHATE 250.
ZINC 5.

PROPOSED RADIATION STANDARD

RADIUM 226 3 PC1/L
GROSS BETA 1000 PC1/L
GROSS ALPHA 15 PC1/L
RADIUM 228 5 PC1/L
STRONTIUM 90 8 PC1/L
IODINE 131 2 PC1/L
TRITIUM 8 X 10E04/L

INTERIM PRIMARY MCL'S (MG/L)

ARSENIC 0.05
BARIUM 1.
CADMIUM 0.010
CHROMIUM 0.05
LEAD 0.05
MERCURY 0.002
NITRATE (N) 10.
SELENIUM 0.01
SILVER 0.05
FLUORIDE 0.05

AVG. MAX. DAILY AIR TEMP.

10 53.8 2.4
10 58.3 2.2
10 63.8 2.0
10 70.6 1.4
10 79.2 1.6
10 90.5 1.4
ENDRI 0.0032
LINDANE 0.004
METHOXYCHLOR 0.1
TOLAPHE 0.035
2,4-D 0.1
2,4,5-TP 0.01
TURBIDITY 1 UNIT

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:

1. THE RESULTS OF A SINGLE TEST IN RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

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PAGE 8

WASHINGTON AQUEDUCT

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	MAX.	TEST	MIN.	TREATED	MAX.	TEST

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PAGE 2

WASHINGTON AQUEDUCT

10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION IN AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - NEW LABOR COST

MAN HOURS - TOTAL MAN HOURS WORKED

MG BILLED CONSUMPTION - REVENUE PRODUCING WATER

\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION

\$/MH - MAN HOURS DIVIDED BY BILLED CONSUMPTION

\$/MH - PAYROLL DIVIDED BY MAN HOURS

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WASHINGTON AQUEDUCT

10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
PAYROLL \$	1938169.	2117162.	2168281.	2366027.	2366027.	2832575.	3015238.	2991493.	3671800.	3591191.	
MAN HOURS	566386.	581986.	553072.	573248.	575746.	591552.	597376.	568256.	576576.	561632.	
MG BILLED CONSUMPTION	65946.	67527.	70988.	70486.	73011.	74322.	74171.	74583.	70338.	72245.	
\$/MG	29.	31.	31.	33.	32.	38.	41.	40.	49.	51.	
MH/MG	9.	9.	8.	8.	8.	8.	8.	8.	8.	8.	
\$/MH	3.62	3.66	3.92	4.09	4.07	4.79	5.05	5.26	6.02	6.57	

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PAGE 11

WASHINGTON AQUEDUCT 10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN
ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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WASHINGTON AQUEDUCT 10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
POWER \$	414266.	408409.	492273.	517140.	609408.	592637.	685599.	751068.	1748676.	1306627.	
K M H	--	--	--	480940.	482750.	476520.	501430.	514000.	479380.	475693.	
\$/MG	6.	6.	7.	7.	8.	8.	9.	13.	25.	18.	
K M H/MG	--	--	--	7.	7.	6.	7.	7.	7.	7.	

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PAGE 13

WASHINGTON AQUEDUCT
10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION)

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WASHINGTON AQUeduct 10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
DEPRECIATION COST \$											

SUPPORT SERVICES	652823.	652903.	665610.	670210.	684450.	686036.	689487.	694318.	713108.	732674.	
ACQUISITION	244809.	244839.	249604.	254329.	256669.	257263.	258558.	260369.	266290.	274753.	
TREATMENT	587541.	587613.	599069.	610389.	616505.	617632.	620538.	624887.	633097.	659433.	
DISTRIBUTION	146885.	146903.	149762.	152597.	154201.	154358.	155135.	156222.	159776.	164852.	
TOTAL	1632057.	1632258.	1664026.	1695524.	1711124.	1715090.	1723717.	1735796.	1775269.	1831683.	

DEPRECIATION COST \$/MG

SUPPORT SERVICES	10.	10.	9.	10.	9.	9.	9.	9.	10.	13.	
ACQUISITION	4.	4.	4.	4.	4.	3.	3.	3.	4.	4.	
TREATMENT	9.	9.	8.	9.	8.	8.	8.	8.	9.	9.	
DISTRIBUTION	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	
TOTAL	25.	24.	23.	24.	23.	23.	23.	23.	25.	25.	

DEPRECIATION COST \$ OF TOTAL

SUPPORT SERVICES	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	
ACQUISITION	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	
TREATMENT	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	
DISTRIBUTION	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

INTEREST COST \$

INTEREST \$	456219.	464985.	469466.	436417.	413446.	544276.	576387.	584467.	614004.	704393.	
INTEREST \$/MG	7.	7.	6.	6.	6.	7.	8.	8.	9.	13.	

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WASHINGTON AQUEDUCT 10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

OCM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

OCM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

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WASHINGTON AQUEDUCT
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
0 C M	3314553.	3563182.	3763720.	4139393.	4619749.	4903527.	5251766.	5649604.	5991541.	7420262.	
DEPRECIATION	1632057.	1632258.	1664026.	1695524.	1711124.	1715090.	1723717.	1735796.	1775269.	1931634.	
INTEREST	454219.	464985.	440966.	434417.	413446.	544276.	576387.	584467.	614004.	704383.	
TOTAL	5400829.	5660425.	5868720.	6269334.	6744319.	7162893.	7551870.	7969867.	9383814.	9956325.	
\$/MG	82.	84.	83.	89.	92.	96.	102.	107.	133.	139.	
\$/MG 1975 DOLLARS	132.	130.	122.	124.	123.	124.	123.	116.	133.	123.	
SPECIAL TAXES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
0 C M & OF TOTAL	61.37	62.95	64.13	66.03	68.50	68.46	69.54	70.99	74.53	74.53	

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PAGE 17

WASHINGTON AQUEDUCT CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS. THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

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WASHINGTON AQUEDUCT COST SUMMARY FOR 1976

***** SUPPORT SERVICES ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL w/TAX * *****						
\$/MG	40.	9.	58.	22.	10.	138.
% OF TOTAL	28.72	6.58	42.00	15.63	7.07	100.00
% OF TOTAL w/TAX	28.72	6.58	42.00	15.63	7.07	100.00
						138.

IN SUMMARY:

DURING THE PAST 10 YEARS, \$ 89286400. TOTAL COST IN 1975 DOLLARS PRODUCED
713516. MG WATER FOR AN AVERAGE COST OF \$ 125./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR THE DEPARTMENT OF ENVIRONMENTAL SERVICES (DES)

(This printout represents cost from the D.C. Department of
Environmental Services as a separate utility. RPW figures represent
billed consumption records from D.C. DES)

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/10/77

UTILITY REPRESENTATIVE

Mr. Mario J. Aiello
Chief, Budget Branch
D.C. DES
415 12th Street, N.W.
Washington, D.C. 20004

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PAGE 1

D. C. DES

SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR	MULTIPLY BY 0.12
PARTS PER MILLION	
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
\$, MH, OR KWH/MILLION GALLONS TO \$, MH, OR	MULTIPLY BY 0.26
KWH/THOUSAND CUBIC METERS	
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY

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3/30/77

PAGE 2

D. C. DES
SYSTEM FACTS
1976

POPULATION - SMSA

COUNTY

CITY OR TOWN

RETAIL SERVICE AREA

AREA OF RETAIL SERVICE AREA

NUMBER OF METERS

NUMBER OF ACCOUNTS

NUMBER OF FLAT RATE ACCOUNTS

PURCHASED WATER - RAW

TREATED

SOURCE WATER - GROUND

SURFACE

PIPE IN SYSTEM

ELEVATIONS - INTAKES

TREATMENT PLANTS

SERVICE AREA MIN.

SERVICE AREA MAX.

REVENUE PRODUCING WATER

TREATED WATER

MAX. DAY

MAX. HOUR

FISCAL YEAR

IMPLEMENTATION DATE

PROCESSING DATE

830003

750003.

75.00 SQ MI

3.

0.

0.

3.0 %

103.0 %

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30 FT

420 FT

55355.0000 MG

72246.0000 MG

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3-J-002
3/30/77

PAGE 3

D. C. DES

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - OCM COST PER YEAR IN DOLLARS

COST/MG - OCM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OCM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

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3-3-002
3/30/77

D. C. DES
10-YEAR KEY D C M COST ANALYSIS

.....
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....

COST/YEAR

SUPPORT SERVICES	1292500.	1319500.	1364500.	1583200.	1859200.	1988800.	2274800.	2184100.	2171900.	1774500.
ACQUISITION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	3223000.	3413600.	3826700.	4148600.	4188500.	4241300.	4244200.	4642800.	4760500.	5098000.
TOTAL	4515500.	4733100.	5191200.	5731800.	6046700.	6230100.	6519000.	6826900.	5932400.	7772500.

COST/MG

SUPPORT SERVICES	--	28.	23.	26.	29.	31.	36.	35.	36.	35.
ACQUISITION	--	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	--	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	--	72.	63.	68.	65.	56.	68.	73.	78.	92.
TOTAL	--	100.	86.	94.	94.	97.	104.	108.	113.	129.

% OF TOTAL

SUPPORT SERVICES	28.62	27.88	26.28	27.62	30.73	31.92	34.89	31.99	31.33	27.92
ACQUISITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DISTRIBUTION	71.38	72.12	73.72	72.38	69.27	68.08	65.11	68.01	68.67	72.08
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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D. C. DES

TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

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D. C. DES

TREATMENT INFORMATION

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10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*
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D. C. DES

RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

PROPOSED SECONDARY STANDARD (MG/L)

INTERIM PRIMARY MCL'S (MG/L)

ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1	ODOR	3 T.O.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FUAMING AGENTS	0.05
MERCURY	0.002	IRON	0.3
MITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.

PROPOSED RADIATION STANDARD

RADIUM 226	3 PC1/L
GROSS BETA	1000 PC1/L
GROSS ALPHA	15 PC1/L
RADIUM 228	5 PC1/L
STRONTIUM 90	8 PC1/L
IODINE 131	2 PC1/L
TRITIUM	8 X 10E04/L

AVG. MAX. DAILY AIR TEMP.

TO 53.8	2.4
TO 58.3	2.2
TO 63.8	2.0
TO 70.6	1.8
TO 79.2	1.6
TO 90.5	1.4

ENDRIN	0.0002
LINDANE	0.004
METHOXYCHLOR	0.1
TOXAPHENE	0.005
2,4-D	0.1
2,4,5-TP	0.01
TURBIDITY	1 UNIT

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:

1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

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RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	RAW	MAX.	TEST	MIN.	TREATED	TEST	MAX.

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3/30/77

PAGE 9

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10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - OLM LABOR COST

MAN HOURS - TOTAL MAN HOURS WORKED

MG BILLED CONSUMPTION - REVENUE PRODUCING WATER

\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION

MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION

\$/MH - PAYROLL DIVIDED BY MAN HOURS

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EPA-207 (Rev. 1
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3-D-002
3/30/77

D. C. DES
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
PAYROLL \$	--	--	--	--	--	--	--	--	--	--
MAN HOURS	--	--	--	--	--	--	--	--	--	--
MG BILLED CONSUMPTION	--	47415.	60362.	61084.	64353.	64112.	62514.	63175.	61169.	55355.
\$/MG	--	--	--	--	--	--	--	--	--	--
MH/MG	--	--	--	--	--	--	--	--	--	--
\$/MH	--	--	--	--	--	--	--	--	--	--

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3-3-002
3/30/77

PAGE 11

D. C. DES

10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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354

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3-J-002
3/30/77

D. C. DES
10-YEAR POWER COST ANALYSIS

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
189600.	188700.	197300.	238300.	260200.	252400.	277500.	373900.	523400.	563000.
17053000.	18025000.	16096000.	19754000.	20050000.	20459000.	19463000.	19639000.	18064000.	18768000.
--	4.	3.	4.	4.	4.	4.	6.	9.	13.
--	380.	267.	323.	312.	319.	311.	311.	295.	333.
POWER \$									
KWH									
\$/MG									
KWH/MG									

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3-D-002
3/30/77

PAGE 13

D. C. DE S

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS) AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION)

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356

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3-9-002
3/30/77

D. C. DES

10-YEAR DEPRECIATION ALLOCATION

.....
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....
DEPRECIATION COST \$

SUPPORT SERVICES	34702.	34715.	35379.	36050.	36378.	36458.	36146.	36904.	37755.	38945.
ACQUISITION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	1700390.	1701027.	1733595.	1766426.	1782498.	1786452.	1771137.	1808300.	1849976.	1908373.
TOTAL	1735092.	1735742.	1768974.	1802476.	1818876.	1822910.	1807283.	1845204.	1887731.	1947315.

DEPRECIATION COST \$/MG

SUPPORT SERVICES	--	1.	1.	1.	1.	1.	1.	1.	1.	1.
ACQUISITION	--	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	--	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	--	36.	29.	29.	28.	28.	28.	29.	30.	34.
TOTAL	--	37.	29.	30.	28.	28.	29.	29.	31.	35.

DEPRECIATION COST \$ OF TOTAL

SUPPORT SERVICES	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
ACQUISITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DISTRIBUTION	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

INTEREST COST \$

INTEREST \$	315644.	355095.	346473.	365614.	360798.	496405.	544690.	625610.	712039.	813687.
INTEREST \$/MG	--	7.	6.	6.	6.	8.	9.	10.	12.	15.

3-0-002
3/30/77

PAGE 15

D. C. DES

10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

UOM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

UOM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

3-3-002
3/33/77

D. C. DES

10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
D E M	4515500.	4733100.	5191200.	5731800.	6046700.	6230100.	6519000.	6826900.	6932400.	7072500.
DEPRECIATION	1735092.	1735742.	1768974.	1802476.	1819876.	1922910.	1807283.	1945204.	1887731.	1947315.
INTEREST	315644.	355095.	346473.	365614.	360798.	496405.	544690.	625610.	712039.	813683.
TOTAL	6566236.	6823937.	7306647.	7899890.	8226374.	8549415.	8870973.	9297714.	9532170.	9833495.
\$/MG	--	144.	121.	129.	128.	133.	142.	147.	156.	173.
\$/MG 1975 DOLLARS	--	223.	178.	180.	170.	172.	172.	160.	156.	162.
SPECIAL TAXES	--	--	--	--	--	--	--	--	--	--
D E M & OF TOTAL	--	69.36	71.05	72.56	73.50	72.87	73.49	73.43	72.73	71.32

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3-2-002
3/30/77

PAGE 17

D. C. DES CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

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3--J-002
3/30/77

D. C. DES COST SUMMARY FOR 1976

***** * SUPPORT SERVICES* ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX * *****						
\$/MG	36.	0.	0.	127.	15.	178.
					--	178.
% OF TOTAL	20.48	0.00	0.03	71.25	8.27	100.00
% OF TOTAL W/TAX	20.48	0.00	0.03	71.25	8.27	100.00

IN SUMMARY:

DURING THE PAST 9 YEARS, \$ 93617536. TOTAL COST IN 1975 DOLLARS PRODUCED
539539. MG WATER FOR AN AVERAGE COST OF \$ 174./MG (1975 DOLLARS)

PAGE 19

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COMPUTER PRINTOUT FOR ROCKVILLE WATER UTILITY

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/31/77

UTILITY REPRESENTATIVE

Mr. Ward L. Rothgeb
Director Public Works
City of Rockville
Maryland at Vinson
Rockville, MD 20850

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RUCKVILLE
SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR	
PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
\$, MH, OR KWH/MILLION GALLONS TO \$, MH, OR	
KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

ROCKVILLE
SYSTEM FACTS
1977

POPULATION - SMSA	
COUNTY	590000
CITY OR TOWN	47000
RETAIL SERVICE AREA	43670.
AREA OF RETAIL SERVICE AREA	12.80 SQ MI
NUMBER OF METERS	10154.
NUMBER OF ACCOUNTS	10155.
NUMBER OF FLAT RATE ACCOUNTS	1.
PURCHASED WATER - RAW	00 MG
TREATED	00 MG
SOURCE WATER - GROUND	0.0 %
SURFACE	100.0 %
PIPE IN SYSTEM	132.5 MI
ELEVATIONS - INTAKES	150 FT
TREATMENT PLANTS	225 FT
SERVICE AREA MIN.	250 FT
SERVICE AREA MAX.	480 FT
REVENUE PRODUCING WATER	1500.6000 MG
TREATED WATER	1642.5000 MG
MAX. DAY	N.A.
MAX. HOUR	6/30
FISCAL YEAR	3/31/77
IMPLEMENTATION DATE	4/ 5/77
PROCESSING DATE	

ROCKVILLE

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FURNATS..

COST/YEAR - OCM COST PER YEAR IN DOLLARS

COST/MG - OCM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OCM COST/YEAR AS A % OF TOTAL

THE THREE FURNATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

3-2-001
3/31/77

ROCKVILLE
10-YEAR KEY O & M CUST ANALYSIS

.....
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....

CUST/YEAR

SUPPORT SERVICES	60142.	63930.	70743.	79837.	92159.	111007.	112561.	132213.	152300.	196826.
ACQUISITION	17681.	19365.	22325.	40247.	35748.	34668.	40099.	50242.	69212.	75897.
TREATMENT	84748.	80686.	117948.	113112.	128034.	139729.	139534.	139711.	175337.	202918.
DISTRIBUTION	76996.	91702.	102598.	143913.	148012.	154370.	194760.	221060.	351442.	280039.
TOTAL	239567.	255683.	313614.	377109.	403953.	439774.	486954.	543226.	748291.	755680.

CUST/MG

SUPPORT SERVICES	55.	57.	59.	61.	74.	89.	82.	74.	106.	131.
ACQUISITION	16.	17.	19.	31.	29.	28.	29.	28.	48.	51.
TREATMENT	78.	72.	98.	87.	103.	112.	102.	78.	122.	135.
DISTRIBUTION	71.	82.	85.	111.	119.	124.	142.	124.	245.	187.
TOTAL	221.	230.	261.	290.	325.	354.	355.	305.	522.	504.

% OF TOTAL

SUPPORT SERVICES	25.10	25.00	22.56	21.17	22.81	25.24	23.12	24.34	20.35	26.05
ACQUISITION	7.38	7.57	7.12	10.67	8.85	7.88	8.23	9.25	9.25	10.04
TREATMENT	35.38	31.56	37.61	29.99	31.70	31.77	28.65	25.72	23.43	26.85
DISTRIBUTION	32.14	35.87	32.71	38.16	36.64	35.10	40.00	40.69	46.97	37.06
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

ROCKVILLE
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-2-001
3/31/77

ROCKVILLE

TREATMENT INFORMATION

TREATMENT PROCESSES	100.0	TREATMENT CHEMICALS	51.6
COAGULATION	100.0	CHLORINE	51.6
FILTRATION	100.0	CARBON	3.2
CHLORINATION	100.0	LIME	172.0
ACTIVATED CARBON	100.0	ALUM	329.4
STABILIZATION	100.0	M2SIF6	37.0

10-YEAR CHEMICAL COST ANALYSIS

TOTAL COST	16812.	18314.	25927.	31723.	32705.	29445.	28428.	31010.	50714.	67204.
TREATED WATER	1186.	1219.	1314.	1423.	1361.	1361.	1500.	1949.	1569.	1642.
BILLED MG	1084.	1114.	1200.	1300.	1244.	1244.	1371.	1781.	1434.	1501.
\$/MG TREATED	14.	15.	20.	22.	24.	22.	19.	16.	32.	41.
\$/MG BILLED	16.	16.	22.	24.	26.	24.	21.	17.	35.	45.

ROCKVILLE
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)		PROPOSED SECONDARY STANDARD (MG/L)	
-----		-----	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	ODOR	3 T.O.N.
CADMIUM	0.010	CHLORINE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FLUORIDING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
-----		-----	
TO 53.8	2.4	RADIUM 226	3 PC/L
TO 58.3	2.2	GROSS BETA	1000 PC/L
TO 63.8	2.0	GROSS ALPHA	15 PC/L
TO 70.6	1.8	RADIUM 228	5 PC/L
TO 79.2	1.6	STRONTIUM 90	8 PC/L
TO 90.5	1.4	IODINE 131	2 PC/L
ENDRIN	0.0002	TRITIUM	8 X 10 ⁶ /L
LINDANE	0.004		
METHOXYCHLOR	0.1		
TOXAPHENE	0.005		
2,4-D	0.1		
2,4,5-TP	0.01		
TURBIDITY	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:
1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

ROCKVILLE

TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-2-001
3/31/77

ROCKVILLE

TREATMENT INFORMATION

TREATMENT PROCESSES	WATER TREATED	TREATMENT CHEMICALS	LB/MG TREATED
COAGULATION	100.2	CHLORINE	51.6
FILTRATION	100.2	CARBON	3.2
CHLORINATION	100.2	LIME	172.0
ACTIVATED CARBON	100.2	ALUM	329.4
STABILIZATION	100.2	H2SIF6	37.0

10-YEAR CHEMICAL COST ANALYSIS

TOTAL COST	16812.	18314.	25927.	31723.	32705.	29445.	28428.	31010.	50714.	67204.
TREATED WATER	1186.	1219.	1314.	1423.	1361.	1361.	1500.	1949.	1569.	1642.
BILLED MG	1084.	1114.	1200.	1300.	1244.	1244.	1371.	1781.	1434.	1501.
\$/MG TREATED	14.	15.	20.	22.	24.	22.	19.	16.	32.	41.
\$/MG BILLED	16.	16.	22.	24.	26.	24.	21.	17.	35.	45.

ROCKVILLE
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)	PROPOSED SECONDARY STANDARD (MG/L)
ARSENIC 0.05	COLOR 15 UNITS
BARIUM 1.	ODOR 3 T.O.N.
CADMIUM 0.010	CHLORIDE 250.
CHROMIUM 0.05	COPPER 0.2
LEAD 0.05	FOAMING AGENTS 0.05
MERCURY 0.002	IRON 0.3
NITRATE (N) 10.	MANGANESE 0.05
SELENIUM 0.01	SULPHATE 250.
SILVER 0.05	ZINC 5.
FLUORIDE	
AVG. MAX. DAILY AIR TEMP.	PROPOSED RADIATION STANDARD
TO 53.8 2.4	
TO 58.3 2.2	
TO 63.8 2.0	
TO 70.6 1.8	
TO 79.2 1.6	
TO 90.5 1.4	
ENDRIN 0.0002	
LINDANE 0.004	
METHOXYCHLOR 0.1	
TOXAPHENE 0.005	
2,4-D 0.1	
2,4,5-TP 0.01	
TURBIDITY 1 UNIT	

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:
1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

ROCKVILLE

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	MAX.	TEST	RAW	TREATED	MAX.	TEST

ROCKVILLE
10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - OCM LABOR COST
MAN HOURS - TOTAL MAN HOURS WORKED
MG BILLED CONSUMPTION - REVENUE PRODUCING WATER
\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION
MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION
\$/MH - PAYROLL DIVIDED BY MAN HOURS

3-2-001
3/31/77

ROCKVILLE

10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
PAYROLL \$	142584.	161443.	195237.	224841.	238231.	246624.	229421.	248262.	205543.	276006.
MAN HOURS	47840.	47840.	47840.	47840.	47840.	47840.	47840.	47840.	47840.	49712.
MG BILLED CONSUMPTION	1084.	1114.	1200.	1300.	1244.	1244.	1371.	1781.	1434.	1501.
\$/MG	132.	145.	163.	173.	192.	198.	167.	139.	199.	184.
MH/MG	44.	43.	40.	37.	38.	38.	35.	27.	33.	33.
\$/MH	2.98	3.37	4.08	4.70	4.98	5.16	4.00	5.19	5.97	5.55

ROCKVILLE
10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN
ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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3/31/77

ROCKVILLE

10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	35362.	38730.	44651.	80494.	71497.	69336.	80198.	100484.	138424.	151795.
KWH	--	--	--	--	--	--	--	--	--	--
\$/KWH	33.	35.	37.	62.	57.	56.	59.	56.	97.	101.
KWH/PG	--	--	--	--	--	--	--	--	--	--

ROCKVILLE

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST & TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION
GALLONS BILLED CONSUMPTION)

376

RUCKVILLE
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

OCM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

OCM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

3/31/77

RUCKVILLE

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
U. S. M.	239567.	255683.	313614.	377109.	403953.	439774.	486954.	543226.	740291.	755680.
DEPRECIATION	41947.	45048.	48754.	50500.	62874.	60029.	61830.	63685.	65595.	67563.
INTEREST	127756.	124016.	124270.	122492.	120525.	117397.	116079.	114916.	107526.	104680.
TOTAL	409270.	426747.	486638.	550101.	587352.	617200.	664863.	721827.	921412.	928123.
\$/MG	378.	383.	405.	423.	472.	496.	485.	405.	643.	619.
\$/MG 1975 DOLLARS	608.	594.	596.	588.	628.	640.	587.	442.	643.	563.
SPECIAL TAXES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
U. S. M. & OF TOTAL	58.54	59.91	64.45	68.55	68.78	71.25	73.24	75.26	81.21	81.42

RUCKVILLE
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

3/31/77

RUCKVILLE

COST SUMMARY FOR 1976

\$/MG	131.	53.	140.	225.	70.	619.	0.	619.
% OF TOTAL	21.21	8.54	22.59	36.36	11.30	100.00		
% OF TOTAL w/ TAX	21.21	8.54	22.59	36.36	11.30	100.00	0.00	100.00

IN SUMMARY:

DURING THE PAST 10 YEARS, \$ 7735023. TOTAL COST IN 1975 DOLLARS PRODUCED

13272. MG WATER FOR AN AVERAGE COST OF \$ 503./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR FALLS CHURCH WATER SUPPLY

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/31/77

8-1/2"

UTILITY REPRESENTATIVE

Mr. H.W. Smith, Director
Dept of Public Utilities
City of Falls Church
300 Park Avenue
Falls Church, VA 22046
(703) 532-0800

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FALLS CHURCH
SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR	
PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
g, MH, OR KWH/MILLION GALLONS TO g, MH, OR	
KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

3-4-007
2/15/77

FALLS CHURCH
SYSTEM FACTS
1976

PUPULATION - SMSA	N.A.
COUNTY	14985
CITY OR TOWN	107365.
RETAIL SERVICE AREA	33.00 SQ MI
AREA OF RETAIL SERVICE AREA	34634.
NUMBER OF METERS	34634.
NUMBER OF ACCOUNTS	0.
NUMBER OF FLAT RATE ACCOUNTS	6487.9 MG
PURCHASED WATER - RAW	100 MG
TREATED	0.0 %
SOURCE WATER - GROUND	100.0 %
SURFACE	349 MI
PIPE IN SYSTEM	50 FT
ELEVATIONS - INTAKES	
TREATMENT PLANTS	510
SERVICE AREA MIN.	FT
SERVICE AREA MAX.	5164.4000 MG
REVENUE PRODUCING WATER	6487.9000 MG
TREATED WATER	26.2 MG
MAX. DAY	
MAX. HOUR	
FISCAL YEAR	6/30
IMPLEMENTATION DATE	2/15/77
PROCESSING DATE	4/25/77

FALLS CHURCH
10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED
IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - OLM COST PER YEAR IN DOLLARS

COST/MG - OLM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OLM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO
ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS
ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING
IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMIS-
SION AND DISTRIBUTION OF WATER FROM THE TREATMENT
FACILITY TO THE CUSTOMER

3-4-007
2/15/77

FALLS CHURCH

10-YEAR KEY O C M COST ANALYSIS

.....
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....

COST/YEAR

SUPPORT SERVICES	--	--	--	--	--	437738.	467130.	534068.	562591.	651885.
ACQUISITION	--	--	--	--	--	687875.	734064.	839248.	872663.	956261.
TREATMENT	--	--	--	--	--	0.	0.	0.	0.	0.
DISTRIBUTION	--	--	--	--	--	437738.	467130.	534068.	552494.	553650.
TOTAL	--	--	--	--	--	1563351.	1668324.	1907384.	1987728.	2161796.

COST/MG

SUPPORT SERVICES	--	--	--	--	--	98.	102.	110.	110.	126.
ACQUISITION	--	--	--	--	--	154.	161.	174.	171.	185.
TREATMENT	--	--	--	--	--	0.	0.	0.	0.	0.
DISTRIBUTION	--	--	--	--	--	98.	102.	110.	108.	107.
TOTAL	--	--	--	--	--	350.	365.	394.	390.	419.

% OF TOTAL

SUPPORT SERVICES	--	--	--	--	--	28.00	28.00	28.00	28.30	30.15
ACQUISITION	--	--	--	--	--	44.00	44.00	44.00	43.90	44.23
TREATMENT	--	--	--	--	--	0.00	0.00	0.00	0.00	0.00
DISTRIBUTION	--	--	--	--	--	28.00	28.00	28.00	27.80	25.61
TOTAL	--	--	--	--	--	100.00	100.00	100.00	100.00	100.00

FALLS CHURCH
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-4-007
2/15/77

FALLS CHURCH

TREATMENT INFORMATION

.....
* TREATMENT PROCESSES * & WATER TREATED *
.....
* TREATMENT CHEMICALS * LB/MG TREATED *
.....

10-YEAR CHEMICAL COST ANALYSIS

.....
* 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
.....
TOTAL COST -- -- -- -- -- 0. 0. 0. 0.
TREATED WATER -- -- -- -- -- 5095. 5333. 5787. 6242. 6488.
BILLED MG -- -- -- -- -- 4465. 4566. 4835. 5093. 5164.
\$/MG TREATED -- -- -- -- -- 0. 0. 0. 0. 0.
\$/MG BILLED -- -- -- -- -- 0. 0. 0. 0. 0.

FALLS CHURCH
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)		PROPOSED SECONDARY STANDARD (MG/L)	
-----		-----	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	ODOR	3 T.O.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FUAGING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
-----		-----	
TO 53-8		RADIUM 226	3 PC/L
TO 58-3		GROSS BETA	1000 PC/L
TO 63-8		GROSS ALPHA	15 PC/L
TO 70-6		RADIUM 228	5 PC/L
TO 79-2		STRONTIUM 90	8 PC/L
TO 90-5		IODINE 131	2 PC/L
ENDRIN		TRITIUM	8 X 10E04/L
LINDANE	0.0002		
METHOXYCHLOR	0.004		
TOXAPHENE	0.1		
2,4-D	0.05		
2,4,5-TP	0.1		
TURBIDITY	0.01		
	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:

1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

FALLS CHURCH

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	MAX.	TEST	TREATED	TEST
				MIN.	MAX.

FALLS CHURCH
10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - OER LABOR COST
MAN HOURS - TOTAL MAN HOURS WORKED
MG BILLED CONSUMPTION - REVENUE PRODUCING WATER
\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION
4¢/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION
\$/MH - PAYROLL DIVIDED BY MAN HOURS

3-4-007
2/15/77

FALLS CHURCH
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
PAYROLL \$	--	--	--	--	--	--	--	--	--	--
MAN HOURS	--	--	--	--	--	--	--	--	--	--
MG BILLED CONSUMPTION	--	--	--	--	--	4465.	4566.	4835.	5093.	5164.
\$/MG	--	--	--	--	--	--	--	--	--	--
MM/MG	--	--	--	--	--	--	--	--	--	--
\$/MM	--	--	--	--	--	--	--	--	--	--

PAGE 10

FALLS CHURCH
10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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FALLS CHURCH 10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	--	--	--	--	--	--	--	--	--	--
K W H	--	--	--	--	--	--	--	--	--	--
\$/MG	--	--	--	--	--	--	--	--	--	--
K W H/MG	--	--	--	--	--	--	--	--	--	--

PAGE 12

FALLS CHURCH

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST UP A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS) AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION)

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2/15/77

FALLS CHURCH

10-YEAR DEPRECIATION ALLOCATION

1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
DEPRECIATION COST \$

SUPPORT SERVICES	--	--	--	--	3832.	4142.	4869.	4391.	4537.
ACQUISITION	--	--	--	--	9580.	10355.	12173.	10977.	11342.
TREATMENT	--	--	--	--	0.	0.	0.	0.	0.
DISTRIBUTION	--	--	--	--	178195.	192602.	226409.	204171.	210954.
TOTAL	--	--	--	--	191608.	207099.	243451.	219539.	226832.

DEPRECIATION COST \$/MG

SUPPORT SERVICES	--	--	--	--	1.	1.	1.	1.	1.
ACQUISITION	--	--	--	--	2.	2.	3.	2.	2.
TREATMENT	--	--	--	--	0.	0.	0.	0.	0.
DISTRIBUTION	--	--	--	--	40.	42.	47.	40.	41.
TOTAL	--	--	--	--	43.	45.	50.	43.	44.

DEPRECIATION COST \$ OF TOTAL

SUPPORT SERVICES	--	--	--	--	2.00	2.00	2.00	2.00	2.00
ACQUISITION	--	--	--	--	5.00	5.00	5.00	5.00	5.00
TREATMENT	--	--	--	--	0.00	0.00	0.00	0.00	0.00
DISTRIBUTION	--	--	--	--	93.00	93.00	93.00	93.00	93.00
TOTAL	--	--	--	--	100.00	100.00	100.00	100.00	100.00

INTEREST COST \$

INTEREST \$	--	--	--	--	148000.	147000.	140000.	145662.	131369.
INTEREST \$/MG	--	--	--	--	33.	32.	29.	29.	25.

FALLS CHURCH
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

- DEM - OPERATING AND MAINTENANCE COSTS
- DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE METHOD)
- INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT
- TOTAL - SUM OF THE ABOVE COSTS
- \$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION
- \$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER PRICE INDEX
- SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)
- OLM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

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FALLS CHURCH
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0 C M	--	--	--	--	--	1563351.	1668324.	1907384.	1967728.	2161796.
DEPRECIATION	--	--	--	--	--	191608.	207099.	243451.	219539.	226832.
INTEREST	--	--	--	--	--	148000.	147000.	140000.	145662.	131369.
TOTAL	--	--	--	--	--	1902959.	2022423.	2290835.	2352929.	2519997.
\$/MG	--	--	--	--	--	426.	443.	474.	462.	488.
\$/MG 1975 DOLLARS	--	--	--	--	--	550.	536.	516.	462.	444.
SPECIAL TAXES	--	--	--	--	--	0.	0.	0.	0.	0.
0 C M % OF TOTAL	--	--	--	--	--	62.15	82.49	83.26	84.48	85.79

FALLS CHURCH
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

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FALLS CHURCH

COST SUMMARY FOR 1976

SUPPORT SERVICES ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX *

1/MG	127.	187.	0.	148.	25.	488.	0.	488.
% OF TOTAL	26.05	38.40	0.00	30.34	5.21	100.00		
% OF TOTAL w/TAX	26.05	38.40	0.00	30.34	5.21	100.00	0.00	100.00

IN SUMMARY:

DURING THE PAST 5 YEARS, \$ 12045082. TOTAL COST IN 1975 DOLLARS PRODUCED
24123. MG WATER FOR AN AVERAGE COST OF \$ 495./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR ARLINGTON COUNTY WATER SUPPLY

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/31/77

UTILITY REPRESENTATIVE

Mr. Bill Jefferies
Director of Public Utilities
Arlington County
1400 N. Court House Road
Arlington, VA 22201
(703) 558-2321

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ARLINGTON COUNTY
SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR	
PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
9, MH, OR KWH/MILLION GALLONS TO \$, MH, OR	
KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY

-- INDICATES THAT THE DATA WAS NOT AVAILABLE

ARLINGTON COUNTY
SYSTEM FACTS
1976

POPULATION - SMSA	155438
COUNTY	N.A.
CITY OR TOWN	155438.
RETAIL SERVICE AREA	25.70 SQ MI
AREA OF RETAIL SERVICE AREA	33044.
NUMBER OF METERS	33044.
NUMBER OF ACCOUNTS	0.
NUMBER OF FLAT RATE ACCOUNTS	0 MG
PURCHASED WATER - RAW	7817.21 MG
TREATED	0.0 %
SOURCE WATER - GROUND	100.0 %
SURFACE	428.5 MI
PIPE IN SYSTEM	
ELEVATIONS - INTAKES	
TREATMENT PLANTS	
SERVICE AREA MIN.	
SERVICE AREA MAX.	
REVENUE PRODUCING WATER	6838.3580 MG
TREATED WATER	7817.2100 MG
MAX. DAY	
MAX. HOUR	
FISCAL YEAR	6/30
IMPLEMENTATION DATE	2/16/77
PROCESSING DATE	4/ 5/77

ARLINGTON COUNTY

30-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FURNATS..

COST/YEAR - DEM COST PER YEAR IN DOLLARS

COST/MG - DEM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - DEM COST/YEAR AS A % OF TOTAL

THE THREE FURNATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMISSION AND DISTRIBUTION OF WATER FROM THE TREATMENT FACILITY TO THE CUSTOMER

APPLINGTON COUNTY

10-YEAR KEY OCM CUST ANALYSIS

COST/YEAR

SUPPORT SERVICES

ACQUISITION

FOR A TIME

DISTRIBUTION

TOTAL

TOTAL

SUPPORT SERVICES

ACQUISITION

FREE AT MENY

DISTRIBUTION

TOTAL

SUPPORT SERVICES

ACQUISITION

TREATMENT

DISTRIBUTION

TOTAL

2 OF TOTAL

17.72

ARLINGTON COUNTY
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

TREATMENT INFORMATION

TREATMENT PROCESSES		TREATMENT CHEMICALS		LB/MG TREATED	
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
15	15	15	15	15	15
16	16	16	16	16	16
17	17	17	17	17	17
18	18	18	18	18	18
19	19	19	19	19	19
20	20	20	20	20	20
21	21	21	21	21	21
22	22	22	22	22	22
23	23	23	23	23	23
24	24	24	24	24	24
25	25	25	25	25	25
26	26	26	26	26	26
27	27	27	27	27	27
28	28	28	28	28	28
29	29	29	29	29	29
30	30	30	30	30	30
31	31	31	31	31	31
32	32	32	32	32	32
33	33	33	33	33	33
34	34	34	34	34	34
35	35	35	35	35	35
36	36	36	36	36	36
37	37	37	37	37	37
38	38	38	38	38	38
39	39	39	39	39	39
40	40	40	40	40	40
41	41	41	41	41	41
42	42	42	42	42	42
43	43	43	43	43	43
44	44	44	44	44	44
45	45	45	45	45	45
46	46	46	46	46	46
47	47	47	47	47	47
48	48	48	48	48	48
49	49	49	49	49	49
50	50	50	50	50	50
51	51	51	51	51	51
52	52	52	52	52	52
53	53	53	53	53	53
54	54	54	54	54	54
55	55	55	55	55	55
56	56	56	56	56	56
57	57	57	57	57	57
58	58	58	58	58	58
59	59	59	59	59	59
60	60	60	60	60	60
61	61	61	61	61	61
62	62	62	62	62	62
63	63	63	63	63	63
64	64	64	64	64	64
65	65	65	65	65	65
66	66	66	66	66	66
67	67	67	67	67	67
68	68	68	68	68	68
69	69	69	69	69	69
70	70	70	70	70	70
71	71	71	71	71	71
72	72	72	72	72	72
73	73	73	73	73	73
74	74	74	74	74	74
75					

10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
2. <i>Curculionidae</i>	1	1	1	1	1	1	1	1	1	1
3. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
4. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
5. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
6. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
7. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
8. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
9. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
10. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
11. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
12. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
13. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
14. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
15. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
16. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
17. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
18. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
19. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
20. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
21. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
22. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
23. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
24. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
25. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
26. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
27. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
28. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
29. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
30. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
31. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
32. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
33. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
34. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
35. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
36. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
37. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
38. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
39. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
40. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
41. <i>Chrysomelidae</i>	1	1	1	1	1	1	1	1	1	1
42. <i>Chrysomelidae</i>	1	1	1							

[illegible]

ARLINGTON COUNTY
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)		PROPOSED SECONDARY STANDARD (MG/L)	
-----		-----	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	ODOR	3 T.O.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FOAMING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
-----		-----	
TO 53.8	2.4		
TO 58.3	2.2		
TO 63.8	2.0	RADIUM 226	3 PCI/L
TO 70.6	1.8	GROSS BETA	1000 PCI/L
TO 79.2	1.6	GROSS ALPHA	15 PCI/L
TO 90.5	1.4	RADIUM 228	5 PCI/L
ENDRIN	0.0002	STROMTIUM 90	8 PCI/L
LINDANE	0.004	IUDINE 131	2 PCI/L
METHOXYCHLOR	0.1	TRITIUM	8 X 10E04/L
TUXAPHENE	0.005		
2,4-D	0.1		
2,4,5-TP	0.01		
TURBIDITY	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:

1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

ARLINGTON COUNTY

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	RAW		TREATED	
	MIN.	MAX.	MIN.	MAX.
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50	0	0	0	0
51	0	0	0	0
52	0	0	0	0
53	0	0	0	0
54	0	0	0	0
55	0	0	0	0
56	0	0	0	0
57	0	0	0	0
58	0	0	0	0
59	0	0	0	0
60	0	0	0	0
61	0	0	0	0
62	0	0	0	0
63	0	0	0	0
64	0	0	0	0
65	0	0	0	0
66	0	0	0	0
67	0	0	0	0
68	0	0	0	0
69	0	0	0	0
70	0	0	0	0
71	0	0	0	0
72	0	0	0	0
73	0	0	0	0
74	0	0	0	0
75	0	0	0	0
76	0	0	0	0
77	0	0	0	0
78	0	0	0	0
79	0	0	0	0
80	0	0	0	0
81	0	0	0	0
82	0	0	0	0
83	0	0	0	0
84	0	0	0	0
85	0	0	0	0
86	0	0	0	0
87	0	0	0	0
88	0	0	0	0
89	0	0	0	0
90	0	0	0	0
91	0	0	0	0
92	0	0	0	0
93	0	0	0	0
94	0	0	0	0
95	0	0	0	0
96	0	0	0	0
97	0	0	0	0
98	0	0	0	0
99	0	0	0	0
100	0	0	0	0

3-4-006
2/16/77

PAGE 9

ARLINGTON COUNTY
10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - OLM LABOR COST
MAN HOURS - TOTAL MAN HOURS WORKED
MG BILLED CONSUMPTION - REVENUE PRODUCING WATER
\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION
MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION
\$/MH - PAYROLL DIVIDED BY MAN HOURS

3-4-006
2/16/77

ARLINGTON COUNTY
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
PAYROLL \$	--	--	--	--	--	--	--	--	--	--
MAN HOURS	--	--	--	--	--	--	--	--	--	--
MG BILLED CONSUMPTION	6082.	5795.	6146.	6545.	6545.	7418.	6888.	6889.	6805.	6838.
\$/MG	--	--	--	--	--	--	--	--	--	--
MH/MG	--	--	--	--	--	--	--	--	--	--
\$/MH	--	--	--	--	--	--	--	--	--	--

3-4-006
2/16/77

PAGE 11

ARLINGTON COUNTY

10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN
ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

3/8"

411

PAGE NUMBER

EPA-287 (Cin.)
(4-75)

FOR TABLES
AND ILLUSTRATIONS

3-4-006
2/16/77

ARLINGTON COUNTY
10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	--	--	--	--	--	--	--	--	--	--
K W H	--	--	--	--	--	--	--	--	--	--
\$/MG	--	--	--	--	--	--	--	--	--	--
K W H/MG	--	--	--	--	--	--	--	--	--	--

ARLINGTON COUNTY

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION
GALLONS BILLED CONSUMPTION)

ARLINGTON COUNTY

10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
SUPPORT SERVICES	3228.	3272.	3320.	3379.	3416.	3525.	3756.	4630.	4704.	4803.
ACQUISITION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	158182.	160330.	163092.	165549.	167370.	172723.	183042.	226868.	230510.	235338.
TOTAL	161410.	163602.	166420.	168928.	170786.	176248.	186778.	231498.	235214.	240141.

DEPRECIATION COST \$

DEPRECIATION COST \$/MG

SUPPORT SERVICES	1.	1.	1.	1.	1.	0.	1.	1.	1.	1.
ACQUISITION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TREATMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTRIBUTION	26.	28.	27.	25.	26.	23.	27.	33.	34.	34.
TOTAL	27.	28.	27.	26.	26.	24.	28.	34.	35.	35.

DEPRECIATION COST \$ (IF TOTAL

SUPPORT SERVICES	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
ACQUISITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DISTRIBUTION	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

INTEREST COST \$

INTEREST \$	90825.	81525.	76450.	68375.	133675.	195225.	221350.	207000.	225050.	286678.
INTEREST \$/MG	15.	14.	12.	10.	20.	26.	33.	30.	33.	42.

ARLINGTON COUNTY
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

OLM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

OLM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

ARLINGTON COUNTY
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
U L M	1707490.	1712860.	1982361.	2156625.	2421863.	2602224.	2636754.	2552339.	2865580.	2890275.
DEPRECIATION	161410.	163602.	166420.	168928.	170786.	176248.	186778.	231498.	235214.	240141.
INTEREST	90825.	81525.	74950.	68375.	133675.	195225.	221350.	207000.	225050.	286678.
TOTAL	1959725.	1957987.	2223711.	2393928.	2726304.	2973697.	3044882.	2990837.	3325844.	3417094.
B/MG	322.	338.	362.	366.	417.	401.	455.	434.	489.	500.
B/MG 1975 DOLLARS	519.	524.	532.	508.	554.	517.	551.	473.	489.	455.
SPECIAL TAXES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
U L M A OF TOTAL	87.13	87.48	89.15	90.09	88.83	87.51	86.60	85.34	86.16	84.58

ARLINGTON COUNTY
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

COST SUMMARY FOR 1976

	\$/MG	76.	157.	0.	224.	42.	500.	0.	500.
SUPPORT SERVICES* ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX *									
\$ OF TOTAL	15.28	31.41	0.00	44.91	8.39	100.00			
\$ OF TOTAL W/TAX	15.28	31.41	0.00	44.91	8.39	100.00	0.00		100.00

IN SUMMARY:

65752. MG WATER FOR AN AVERAGE COST OF \$ 511./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR LEESBURG WATER UTILITY

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/31/77

UTILITY REPRESENTATIVE

Mr. Juan Chavis
Director of Public Works
P.O. Box 88
Leesburg, VA 22075
(703) 777-2420

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AND ILLUS-
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3-4-005
3/ 9/77

LEESBURG, VIRGINIA
SYSTEM FACTS

THE SYSTEM FACTS REPORT IDENTIFIES THE PARAMETERS OF THE WATER UTILITY UNDER STUDY. THE REPORT INCLUDES THE POPULATION, SIZE OF THE SERVICE AREA, NUMBER OF CUSTOMERS, SOURCE WATER INFORMATION, PERTINENT TOPOGRAPHICAL DATA, AND FLOW INFORMATION FOR THE YEAR DESIGNATED IN THE HEADING. INFORMATION IN THIS REPORT IS ON A FISCAL YEAR BASIS. FISCAL YEAR 1974-75 FOR EXAMPLE IS DESIGNATED 1975 THROUGHOUT THE PRINTOUT. THE IMPLEMENTATION DATE IS THE DATE THAT DATA WAS COLLECTED AT THE UTILITY.

ALL UNITS IN THIS REPORT ARE IN ENGLISH

THE FOLLOWING TABLE CONVERTS THE UNITS TO METRIC

POUNDS PER MILLION GALLONS TO MILLIGRAMS PER LITER OR PARTS PER MILLION	MULTIPLY BY 0.12
MILLION GALLONS TO THOUSAND CUBIC METERS	MULTIPLY BY 3.79
g, MH, OR KWH/MILLION GALLONS TO g, MH, OR KWH/THOUSAND CUBIC METERS	MULTIPLY BY 0.26
FEET TO METERS	MULTIPLY BY 0.30
MILES TO KILOMETERS	MULTIPLY BY 1.61
SQUARE MILES TO SQUARE KILOMETERS	MULTIPLY BY 2.59

NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

3-4-005
3/ 9/77

LEESBURG, VIRGINIA
SYSTEM FACTS
1977

POPULATION - SMSA	
COUNTY	
CITY OR TOWN	
RETAIL SERVICE AREA	
AREA OF RETAIL SERVICE AREA	8000
NUMBER OF METERS	9000.
NUMBER OF ACCOUNTS	4.16 SQ MI
NUMBER OF FLAT RATE ACCOUNTS	2025.
PURCHASED WATER - RAW	2025.
TREATED	0.
SOURCE WATER - GROUND	00 MG
SURFACE	00 MG
PIPE IN SYSTEM	100.0 %
ELEVATIONS - INTAKES	0.0 %
TREATMENT PLANTS	28.9 MI
SERVICE AREA MIN.	
SERVICE AREA MAX.	
REVENUE PRODUCING WATER	
TREATED WATER	255 FT
MAX. DAY	420 FT
MAX. HOUR	265.5200 MG
FISCAL YEAR	296.1200 MG
IMPLEMENTATION DATE	107 MG
PROCESSING DATE	
	6/30
	3/ 9/77
	3/ 9/77

3-4-005
3/ 9/77

PAGE 3

LEESBURG, VIRGINIA

10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED
IN UTILITY RECORDS PRESENTED IN THE THREE FOLLOWING FORMATS..

COST/YEAR - DEM COST PER YEAR IN DOLLARS

COST/MG - DEM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - DEM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO
ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS
ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING
IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMIS-
SION AND DISTRIBUTION OF WATER FROM THE TREATMENT
FACILITY TO THE CUSTOMER

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AND ILLUS-
TRATIONS

LEESBURG, VIRGINIA

[illegible]CUST/YEAR

SUPPORT SERVICES	--	--	--	607.	2241.	994.	1092.	12673.	33381.
ACQUISITION	--	--	--	5890.	6598.	8186.	21073.	19674.	38828.
TREATMENT	--	--	--	2090.	2652.	3415.	4587.	5651.	8238.
DISTRIBUTION	--	--	--	28648.	39475.	53519.	58910.	64845.	72242.
TOTAL	--	--	--	37236.	50966.	66113.	85662.	102843.	152689.

COST/MG

SUPPORT SERVICES	--	--	--	4.	13.	6.	5.	58.	126.
ACQUISITION	--	--	--	40.	39.	48.	105.	90.	146.
TREATMENT	--	--	--	14.	16.	20.	23.	26.	31.
DISTRIBUTION	--	--	--	196.	232.	312.	292.	297.	272.
TOTAL	--	--	--	255.	300.	385.	425.	472.	575.

% OF TOTAL

SUPPORT SERVICES	--	--	--	1.63	4.40	1.50	1.28	12.32	21.86
ACQUISITION	--	--	--	--	15.82	12.38	24.60	19.13	25.83
TREATMENT	--	--	--	--	5.61	5.17	5.35	5.50	5.40
DISTRIBUTION	--	--	--	--	76.94	80.95	68.77	63.05	47.31
TOTAL	--	--	--	--	100.00	100.00	100.00	100.00	100.00

3-4-005
3/ 9/77

PAGE 5

LEESBURG, VIRGINIA
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-4-005

3/ 9/77

LEESBURG, VIRGINIA

TREATMENT INFORMATION

CHLORINATION	100%	CHLORINE	5.4
TREATMENT PROCESSES * & WATER TREATED *		TREATMENT CHEMICALS *	LB/MG TREATED *

10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
TOTAL COST	--	--	--	--	97.	69.	75.	204.	304.	--
TREATED WATER	--	--	--	--	187.	218.	220.	258.	279.	296.
BILLED MG	--	--	--	--	146.	170.	172.	201.	218.	266.
\$/MG TREATED	--	--	--	--	1.	0.	0.	1.	1.	--
\$/MG BILLED	--	--	--	--	1.	0.	0.	1.	1.	--

3-4-005

9/9/77

PAGE 7

LEESBURG, VIRGINIA

RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L) PROPOSED SECONDARY STANDARD (MG/L)

INTERIM PRIMARY MCL'S (MG/L)	PROPOSED SECONDARY STANDARD (MG/L)
ARSENIC 0.05	COLOR 15 UNITS
BARIUM 1.	ODOR 3 I.O.M.
CADMIUM 0.010	CHLORIDE 250.
CHROMIUM 0.05	COPPER 0.2
LEAD 0.05	FUAMING AGENTS 0.05
MERCURY 0.002	IRON 0.3
NITRATE (N) 10.	MANGANESE 0.05
SELENIUM 0.01	SULPHATE 250.
SILVER 0.05	ZINC 5.
FLUORIDE	

AVG. MAX. DAILY AIR TEMP.

TO 53.8	2.4
TO 58.3	2.2
TO 63.8	2.0
TO 70.6	1.8
TO 79.2	1.6
TO 90.5	1.4

ENDRIN 0.0002	
LINDANE 0.004	
METHOXYCHLOR 0.1	
TOXAPHENE 0.005	
2,4-D 0.1	
2,4,5-TP 0.01	
TURBIDITY 1 UNIT	

PROPOSED RADIATION STANDARD

RADIUM 226	3 PC1/L
GROSS BETA	1000 PC1/L
GROSS ALPHA	15 PC1/L
RADIUM 228	5 PC1/L
STRONTIUM 90	8 PC1/L
IODINE 131	2 PC1/L
TRITIUM	8 X 10E04/L

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:

1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

3-4-005
3/ 9/77

PAGE 8

LEESBURG, VIRGINIA

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	MIN.	RAW	MAX.	TEST	MIN.	TREATED	MAX.	TEST	DATE
CADMIUM									10/01/74
CHROMIUM									
LEAD									
MERCURY									
FLUORIDE									
CHLORIDE									
MANGANESE									
GROSS BETA									
RADIUM 226									
STRONTIUM									
TRITIUM									

3-4-005

3/ 9/77

LEESBURG, VIRGINIA

10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - DLM LABOR COST

MAN HOURS - TOTAL MAN HOURS WORKED

MG BILLED CONSUMPTION - REVENUE PRODUCING WATER

\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION

MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION

\$/MH - PAYROLL DIVIDED BY MAN HOURS

PAGE 9

3-4-005
3/ 9/77

LEESBURG, VIRGINIA
10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
PAYROLL \$	--	--	--	--	26577.	34441.	44535.	58427.	71297.	82565.
MAN HOURS	--	--	--	--	6240.	7280.	8320.	10400.	10400.	10400.
MG BILLED CONSUMPTION	--	--	--	--	146.	170.	172.	201.	218.	266.
\$/MG	--	--	--	--	182.	202.	260.	290.	327.	311.
RH/MG	--	--	--	--	43.	43.	48.	52.	48.	39.
\$/MH	--	--	--	--	4.26	4.73	5.35	5.62	6.86	7.94

3-4-005
3/ 9/77

LEESBURG, VIRGINIA
10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
POWER \$	--	--	--	--	2396.	2513.	2729.	3062.	10377.	11931.
K W H	--	--	--	--	--	--	--	--	--	--
\$/MG	--	--	--	--	16.	15.	16.	15.	48.	45.
K W H/MG	--	--	--	--	--	--	--	--	--	--

3-4-005
3/ 9/77

LEESBURG, VIRGINIA
10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

PAGE 11

DRG
HEA
REC
SEC
MEM

3-4-005

3/ 9/77

LEESBURG, VIRGINIA

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS) AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION)

LEESBURG, VIRGINIA

10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
SUPPORT SERVICES	--	--	--	--	0.	0.	0.	0.	0.	0.
ACQUISITION	--	--	--	--	2030.	2030.	2065.	1549.	1035.	1036.
TREATMENT	--	--	--	--	1523.	1523.	1032.	1032.	1035.	1036.
DISTRIBUTION	--	--	--	--	46701.	47209.	48525.	49041.	49665.	49718.
TOTAL	--	--	--	--	50762.	50762.	51622.	51622.	51734.	51789.

SUPPORT SERVICES
ACQUISITION
TREATMENT
DISTRIBUTION
TOTAL

SUPPORT SERVICES
ACQUISITION
TREATMENT
DISTRIBUTION
TOTAL

INTEREST \$
INTEREST \$/MG

LEESBURG, VIRGINIA

10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING ANNUAL COSTS FOR THE PAST TEN YEARS:

OCM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

OCM & OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

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10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
D E M	--	--	--	--	37236.	50966.	66113.	85662.	102843.	152689.
DEPRECIATION	--	--	--	--	50762.	50762.	51622.	51622.	51734.	51789.
INTEREST	--	--	--	--	41000.	41000.	41000.	42573.	39787.	37183.
TOTAL	--	--	--	--	128998.	142728.	158735.	179857.	194364.	241662.
1/MG	--	--	--	--	883.	839.	925.	893.	892.	910.
1/MG 1975 DOLLARS	--	--	--	--	1174.	1082.	1119.	973.	892.	828.
SPECIAL TAXES	--	--	--	--	0.	0.	0.	0.	0.	0.
U C M & UP TOTAL	--	--	--	--	28487	35771	41465	47463	52491	63418

3-4-005

3/ 9/77

LEESBURG, VIRGINIA

CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

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PAGE 17

3-4-005

3/ 9/77

LEESBURG, VIRGINIA

COST SUMMARY FOR 1976

	ACQUISITION	TREATMENT	DISTRIBUTION	INTEREST	TOTAL	TAXES	TOTAL W/TAX
\$/MG	126.	150.	35.	459.	140.	910.	0. 910.
% OF TOTAL	13.81	16.50	3.84	50.47	15.39	100.00	
% OF TOTAL W/TAX	13.81	16.50	3.84	50.47	15.39	100.00	0.00 100.00

IN SUMMARY:

DURING THE PAST 6 YEARS, \$ 1158075. TOTAL COST IN 1975 DOLLARS PRODUCED 1173. MG WATER FOR AN AVERAGE COST OF \$ 987./ MG (1975 DOLLARS)

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COMPUTER PRINTOUT FOR FAIRFAX COUNTY WATER AUTHORITY

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER SUPPLY COST STUDY

3/31/77

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UTILITY REPRESENTATIVE

Mr. Vincent Byrne
Assistant to the
Engineer-Director
Fairfax County Water Auth.
Fairfax, VA
(703) 280-4000

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AND ILLUS-
TRATIONS

FAIRFAX CO. WATER AUTHORITY
SYSTEM FACTS

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NOTE: BECAUSE OF COMPUTER DESIGN, ACTUAL VALUES AND PRINTED NUMBERS MAY VARY SLIGHTLY
-- INDICATES THAT THE DATA WAS NOT AVAILABLE

FAIRFAX CO. WATER AUTHORITY
SYSTEM FACTS
1976

POPULATION - SMSA	553000
COUNTY	N.A.
CITY OR TOWN	607000.
RETAIL SERVICE AREA	400.00 SQ MI
AREA OF RETAIL SERVICE AREA	91201.
NUMBER OF METERS	91201.
NUMBER OF ACCOUNTS	0.
NUMBER OF FLAT RATE ACCOUNTS	NONE
PURCHASED WATER - RAW	1917.91 MG
TREATED	1.0 %
SOURCE WATER - GROUND	99.0 %
SURFACE	1400.97 MI
PIPE IN SYSTEM	0 FT
ELEVATIONS - INTAKES	260 FT
TREATMENT PLANTS	510 FT
SERVICE AREA MIN.	00 FT
SERVICE AREA MAX.	22168.6200 MG
REVENUE PRODUCING WATER	23805.1800 MG
TREATED WATER	99 MG
MAX. DAY	N.A.
MAX. HOUR	12/31
FISCAL YEAR	3/14/77
IMPLEMENTATION DATE	1/30/79
PROCESSING DATE	

FAIRFAX CO. WATER AUTHORITY
10-YEAR KEY OPERATING AND MAINTENANCE COST ANALYSIS

THE KEY OPERATING AND MAINTENANCE COST ANALYSIS INCLUDES ALL COST IDENTIFIED
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COST/YEAR - OCM COST PER YEAR IN DOLLARS

COST/MG - OCM COST/YEAR DIVIDED BY BILLED CONSUMPTION

% OF TOTAL - OCM COST/YEAR AS A % OF TOTAL

THE THREE FORMATS ARE DIVIDED INTO FOUR CATEGORIES:

SUPPORT SERVICES - ALL COST WHICH CAN NOT BE DIRECTLY ALLOCATED TO
ACQUISITION, TREATMENT AND DISTRIBUTION SUCH AS
ADMINISTRATIVE, ACCOUNTING & COLLECTION, ETC.

ACQUISITION - ALL COSTS ASSOCIATED WITH ACQUIRING WATER AND TRANSMITTING
IT TO THE TREATMENT FACILITY

TREATMENT - ALL COSTS ASSOCIATED WITH PURIFICATION

DISTRIBUTION - ALL COST ASSOCIATED WITH DISTRIBUTION STORAGE, TRANSMIS-
SION AND DISTRIBUTION OF WATER FROM THE TREATMENT
FACILITY TO THE CUSTOMER

3-4-008
3/14/77

FAIRFAX CO. WATER AUTHORITY
10-YEAR KEY D & M COST ANALYSIS

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1967
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1968
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1969
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1970
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1971
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1972
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1973
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1974
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1975
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1976
.....

COST/YEAR

SUPPORT SERVICES	--	673290.	1000198.	1253295.	1232444.	1406369.	1548813.	1965229.	2108269.	2461751.
ACQUISITION	--	200355.	249963.	279203.	298867.	340481.	383244.	420336.	400243.	460263.
TREATMENT	--	461811.	566064.	574482.	554365.	586017.	584170.	592085.	693056.	754243.
DISTRIBUTION	--	981676.	1076634.	1122043.	1370562.	1604843.	1916047.	1764857.	2222726.	2263449.
TOTAL	--	2317132.	2890859.	3229023.	3656438.	3937710.	4432274.	4742507.	5424294.	5941706.

COST/MG

SUPPORT SERVICES	--	45.	62.	74.	70.	76.	81.	96.	104.	111.
ACQUISITION	--	13.	16.	16.	17.	16.	20.	21.	20.	21.
TREATMENT	--	31.	35.	34.	31.	32.	30.	29.	34.	34.
DISTRIBUTION	--	66.	67.	66.	77.	87.	100.	86.	109.	102.
TOTAL	--	156.	180.	189.	195.	213.	230.	232.	267.	268.

% OF TOTAL

SUPPORT SERVICES	--	29.06	34.60	36.81	35.66	35.72	34.94	41.44	38.87	41.47
ACQUISITION	--	8.65	8.65	8.65	8.65	8.65	8.65	8.06	7.38	7.75
TREATMENT	--	19.93	19.51	17.79	16.04	14.88	13.18	12.48	12.78	12.69
DISTRIBUTION	--	42.37	37.24	34.75	39.65	40.76	43.23	37.21	40.98	36.09
TOTAL	--	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

PAIPEX CO. WATER AUTHORITY
TREATMENT INFORMATION

THE WATER TREATMENT INFORMATION REPORT PROVIDES INFORMATION ON WATER TREATMENT PROCESSES THAT THE UTILITY IS CURRENTLY USING, ALONG WITH ASSOCIATED COST. THE TREATMENT INFORMATION IS DIVIDED INTO THREE PARTS. THE FIRST, TREATMENT PROCESSES, LISTS THE TYPES OF TREATMENT THAT ARE USED BY THE UTILITY; THE SECOND, TREATMENT CHEMICALS, IDENTIFIES THE CHEMICALS USED PER MILLION GALLONS OF TREATED WATER DURING THE LAST YEAR; THE THIRD, TEN-YEAR CHEMICAL COST ANALYSIS, PROVIDES THE TOTAL COST OF CHEMICALS USED DURING EACH YEAR FOR THE PAST TEN YEARS, THE AMOUNT OF WATER THAT WAS TREATED, THE BILLED CONSUMPTION, THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS TREATED WATER, AND THE CHEMICAL COST IN DOLLARS PER MILLION GALLONS OF BILLED CONSUMPTION.

3-4-008
3/14/77

FAIRFAX CO. WATER AUTHORITY

TREATMENT INFORMATION

TREATMENT PROCESSES	WATER TREATED	TREATMENT CHEMICALS	LB/MG TREATED
SEDIMENTATION	99.2	CHLORINE	65.1
COAGULATION	99.2	FLUORIDE	0.8
FILTRATION	99.2	LIME	76.6
CHLORINATION	100.2	ALUM	204.7
FLUORIDATION	100.2	COPPER SULFATE	4.5
STABILIZATION	100.2	HYDRATED LIME	24.6
DECHLORINATION	100.2		

10-YEAR CHEMICAL COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
TOTAL COST	--	249153.	350688.	312576.	259208.	269633.	325340.	405467.	527468.	579363.
TREATED WATER	--	--	--	18050.	19119.	19680.	20905.	21411.	21368.	23805.
BILLED MG	--	14866.	16020.	17049.	17699.	18504.	19232.	20408.	20346.	22169.
\$/MG TREATED	--	--	--	17.	14.	14.	16.	19.	25.	26.
\$/MG BILLED	--	17.	22.	18.	15.	15.	17.	20.	26.	26.

FAIRFAX CO. WATER AUTHORITY
RAW/TREATED WATER QUALITY INFORMATION

THE RAW/TREATED WATER QUALITY REPORT PRESENTS WATER QUALITY INFORMATION PERTINENT TO THE SAFE DRINKING WATER ACT. THE STANDARDS ARE LISTED BELOW.

INTERIM PRIMARY MCL'S (MG/L)		PROPOSED SECONDARY STANDARD (MG/L)	
ARSENIC	0.05	COLOR	15 UNITS
BARIUM	1.	ODOR	3 T.U.N.
CADMIUM	0.010	CHLORIDE	250.
CHROMIUM	0.05	COPPER	0.2
LEAD	0.05	FUAMING AGENTS	0.05
MERCURY	0.002	IRON	0.3
NITRATE (N)	10.	MANGANESE	0.05
SELENIUM	0.01	SULPHATE	250.
SILVER	0.05	ZINC	5.
FLUORIDE			
AVG. MAX. DAILY AIR TEMP.		PROPOSED RADIATION STANDARD	
TO 53.8	2.4		
TO 58.3	2.2		
TO 63.8	2.0	RADIUM 226	3 PC/L
TO 70.6	1.8	GROSS BETA	1000 PC/L
TO 79.2	1.6	GROSS ALPHA	15 PC/L
TO 90.5	1.4	RADIUM 228	5 PC/L
ENDRIN	0.0002	STRONTIUM 90	8 PC/L
LINDANE	0.004	IODINE 131	2 PC/L
METHOXYCHLOR	0.1	TRITIUM	8 X 10E04/L
TOXAPHENE	0.005		
2,4-D	0.1		
2,4,5-TP	0.01		
TURBIDITY	1 UNIT		

DATA INCLUDED IN THE QUALITY REPORT IS IN ONE OF THREE FORMATS:
1. THE RESULTS OF A SINGLE TEST ON RAW AND/OR TREATED WATER WITH THE DATE.
2. THE RANGE OF RESULTS OF MORE THAN ONE TEST OVER THE PAST 12 MONTHS FOR RAW AND/OR TREATED WATER. NO DATE IS GIVEN IN THIS CASE.
3. THE RANGE OF RESULTS OF MORE THAN ONE TEST AT MORE THAN ONE WATER SOURCE OR SITE IN THE DISTRIBUTION SYSTEM. THE TEST DATE IS PRINTED OUT.

FAIRFAX CO. WATER AUTHORITY

RAW/TREATED WATER QUALITY INFORMATION

(UNITS ARE THE SAME AS SHOWN ON PAGE ABOVE)

CONSTITUENT	RAW	MAX.	MIN.	TREATED	MAX.	MIN.	TEST

FAIRFAX CO. WATER AUTHORITY
10-YEAR LABOR COST ANALYSIS

THE TEN-YEAR LABOR COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN ANNUAL BASIS FOR THE PAST TEN YEARS:

PAYROLL \$ - DCM LABOR COST
MAN HOURS - TOTAL MAN HOURS WORKED
MG BILLED CONSUMPTION - REVENUE PRODUCING WATER
\$/MG - PAYROLL DIVIDED BY MG BILLED CONSUMPTION
MH/MG - MAN HOURS DIVIDED BY BILLED CONSUMPTION
\$/MH - PAYROLL DIVIDED BY MAN HOURS

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3-4-008

3/14/77

FAIRFAX CO. WATER AUTHORITY

10-YEAR LABOR COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
PAYROLL \$	--	1191623.	1401918.	1623016.	2039253.	2402568.	2696576.	2095389.	2228210.	2489064.	
MAN HOURS	--	352605.	374217.	352712.	449566.	492488.	519994.	561514.	524109.	543420.	
MG BILLED CONSUMPTION	--	14866.	18020.	17049.	17699.	18504.	19232.	20408.	20346.	22169.	
\$/MG	--	80.	88.	95.	115.	130.	140.	103.	110.	112.	
PH/MG	--	24.	23.	21.	25.	27.	27.	28.	26.	25.	
\$/HH	--	3.38	3.75	4.60	4.54	4.88	5.19	3.73	4.25	4.58	

PAGE 10

3-4-008
3/14/77

FAIRFAX CO. WATER AUTHORITY
10-YEAR POWER COST ANALYSIS

THE TEN YEAR POWER COST ANALYSIS INCLUDES THE FOLLOWING INFORMATION ON AN
ANNUAL BASIS FOR THE PAST TEN YEARS:

POWER \$ - POWER COST

KWH - KILOWATT HOURS USED

\$/MG - POWER COST DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

KWH/MG - KILOWATT HOURS DIVIDED BY MILLION GALLONS BILLED CONSUMPTION

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3/14/77

FAIRFAX CO. WATER AUTHORITY
10-YEAR POWER COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
POWER \$	--	225284.	240880.	279512.	286918.	309795.	350195.	300175.	1086933.	1495821.	
K W H	--	--	--	--	--	--	--	--	--	--	
\$/MCH	--	15.	16.	16.	16.	17.	18.	15.	53.	67.	
K W H/MCH	--	--	--	--	--	--	--	--	--	--	

FAIRFAX CO. WATER AUTHORITY

10-YEAR DEPRECIATION COST ALLOCATION

THE TEN YEAR DEPRECIATION COST ALLOCATION REPORT INCLUDES THE FOLLOWING COST FOR THE LAST TEN YEARS. THESE COST ARE ALLOCATED TO THE UTILITIES FUNCTIONS OF SUPPORT SERVICES, ACQUISITION, TREATMENT AND DISTRIBUTION.

DEPRECIATION COST \$ - ANNUAL DEPRECIATION COST IN DOLLARS

DEPRECIATION COST \$/MG - DEPRECIATION COST DIVIDED BY MG BILLED CONSUMPTION

DEPRECIATION COST % OF TOTAL - DEPRECIATION COST OF A UTILITY FUNCTION AS A PERCENT OF TOTAL DEPRECIATION COST

INTEREST COST - INCLUDES INTEREST \$ (TOTAL ANNUAL INTEREST COST IN DOLLARS)
AND INTEREST COST \$/MG (INTEREST COST DIVIDED BY MILLION
GALLONS BILLED CONSUMPTION)

3-4-008
3/14/77

FAIRFAX CO. WATER AUTHORITY

10-YEAR DEPRECIATION ALLOCATION

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
DEPRECIATION COST \$											

SUPPORT SERVICES	--	142548.	142548.	142548.	142548.	142548.	142822.	143097.	143371.	143645.	
ACQUISITION	--	285096.	285096.	285096.	285096.	285096.	285645.	286193.	286742.	287291.	
TREATMENT	--	601869.	601869.	601869.	601869.	601869.	603027.	604186.	605345.	606503.	
DISTRIBUTION	--	554353.	554353.	554353.	554353.	554353.	555420.	556487.	557554.	558621.	
TOTAL	--	1583865.	1583865.	1583865.	1583865.	1583865.	1586914.	1589963.	1593012.	1596061.	

DEPRECIATION COST \$/MG

SUPPORT SERVICES	--	10.	9.	8.	8.	8.	7.	7.	7.	6.	
ACQUISITION	--	19.	18.	17.	16.	15.	15.	14.	14.	13.	
TREATMENT	--	40.	38.	35.	34.	33.	31.	30.	30.	27.	
DISTRIBUTION	--	37.	35.	33.	31.	30.	29.	27.	27.	25.	
TOTAL	--	107.	99.	93.	89.	86.	83.	78.	78.	72.	

DEPRECIATION COST % OF TOTAL

SUPPORT SERVICES	--	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
ACQUISITION	--	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	
TREATMENT	--	38.00	36.00	36.00	38.00	38.00	38.00	38.00	38.00	38.00	
DISTRIBUTION	--	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	
TOTAL	--	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

INTEREST COST \$

INTEREST \$	--	4799993.	3401288.	4934620.	4105420.	4059620.	4011220.	3959920.	3905720.	5105070.	
INTEREST \$/MG	--	323.	212.	289.	232.	219.	209.	194.	192.	230.	

FAIRFAX CO. WATER AUTHORITY
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

THE TEN-YEAR CAPITAL AND OPERATING COST ANALYSIS PROVIDES THE FOLLOWING
ANNUAL COSTS FOR THE PAST TEN YEARS:

OCM - OPERATING AND MAINTENANCE COSTS

DEPRECIATION - ANNUAL DEPRECIATION COST (ORIGINAL COST - STRAIGHT LINE
METHOD)

INTEREST - ANNUAL INTEREST COST ON BOTH SHORT- AND LONG-TERM DEBT

TOTAL - SUM OF THE ABOVE COSTS

\$/MG - TOTAL DIVIDED BY MG BILLED CONSUMPTION

\$/MG 1975 DOLLARS - \$/MG ADJUSTED TO 1975 VALUES USING THE CONSUMER
PRICE INDEX

SPECIAL TAXES - REAL PROPERTY TAXES (NOT INCLUDED IN TOTAL)

DEM % OF TOTAL - OPERATING AND MAINTENANCE COST AS A PERCENT OF TOTAL

3-4-008
3/14/77

FAIRFAX CO. WATER AUTHORITY
10-YEAR CAPITAL AND OPERATING COST ANALYSIS

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
U L M	--	2317132.	2890859.	3229023.	3456438.	3937710.	4432274.	4742507.	5424294.	5941706.	
DEPRECIATION	--	1583865.	1583865.	1583865.	1583865.	1583865.	1586914.	1589963.	1593012.	1596061.	
INTEREST	--	4799993.	3401288.	4934620.	4105420.	4059620.	4011220.	3959920.	3905720.	5105070.	
TOTAL	--	8700990.	7876012.	9747508.	9145723.	9581195.	10030408.	10292390.	10923026.	12642837.	
1/MG	--	585.	492.	572.	517.	518.	522.	504.	537.	570.	
1/MG 1975 DOLLARS	--	907.	723.	795.	687.	668.	631.	550.	537.	519.	
SPECIAL TAXES	--	0.	0.	0.	0.	0.	0.	0.	0.	0.	
U L M & UP TOTAL	--	26.63	36.70	33.13	37.79	41.10	44.19	46.08	49.66	47.00	

FAIRFAX CO. WATER AUTHORITY
CURRENT YEAR COST SUMMARY

THE COST SUMMARY PROVIDES THE SUPPORT SERVICES, ACQUISITION, TREATMENT, DISTRIBUTION, INTEREST, TOTAL, TAXES AND TOTAL WITH TAXES OF WATER ON A DOLLARS PER MILLION GALLONS BASIS. THE SUMMARY ALSO PROVIDES THESE COSTS ON A PERCENT OF SUB-TOTAL AND PERCENT OF TOTAL BASIS.

THE TAXES IDENTIFIED BELOW INCLUDE ONLY REAL PROPERTY TAXES WHICH ARE USUALLY FOUND IN PRIVATE UTILITIES. IF THESE TAXES DO NOT EXIST THE SUB-TOTAL AND TOTAL ARE EQUAL.

3-6-009
3/14/77

FAIRHAX CO. WATER AUTHORITY
COST SUMMARY FOR 1976

***** SUPPORT SERVICES ACQUISITION * TREATMENT * DISTRIBUTION * INTEREST * TOTAL * TAXES * TOTAL W/TAX * *****									
\$/MG	118.	36.	61.	127.	230.	570.	0.	570.	
% OF TOTAL	20.62	5.91	10.76	22.32	40.38	100.00			
% OF TOTAL W/TAX	20.62	5.91	10.76	22.32	40.38	100.00	0.00	100.00	

IN SUMMARY:

DURING THE PAST 9 YEARS, \$ 108920320. TOTAL COST IN 1975 DOLLARS PRODUCED
166293. MG WATER FOR AN AVERAGE COST OF \$ 655./ MG (1975 DOLLARS)

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APPENDIX F

ANALYSIS OF FLOW CORRELATIONS BETWEEN
POTOMAC AND BULL RUN: PATUXENT AND DEER CREEK RIVER

This appendix is an analysis between flows in the Potomac and a selected set of streams in the Potomac and Susquehanna River basins. Table 20 illustrates the problem associated with the use of interconnections between the Potomac, Patuxent, and Occoquan reservoirs. The critical problem with interconnection is that eventually, under extended low flow conditions, the stored capacity of the Patuxent and Occoquan reservoirs is exhausted. All of the analyses performed in the report assume that throughout any low flow period both the Patuxent and Occoquan reservoirs can continue to supply a steady and dependable yield to the area they currently serve. This continuous service mitigates the total water deficit in the area. However, if the Occoquan and Patuxent reservoirs are used while low flow conditions still exist in the Potomac, their normal dependable yield will have to be added to the Potomac deficit flows. If such a situation occurs, there would be no water left to service the WMA. Therefore, it is critical to examine the normal inflow into the Patuxent and Occoquan reservoirs. If this inflow is unrelated to flows in the Potomac, interconnections take on a more favorable light. If, however, low flows in the Potomac are correlated with low flows in the Patuxent and Occoquan, then the situation shown in Figure 36 may occur. Another important relationship is that between river flows in the Potomac basin and flows in the Susquehanna, particularly if an emergency connection were established between the two basins.

POTOMAC BASIN ANALYSIS

Table F-1 shows the relationship between the flow in the Potomac, Bull Run, and Patuxent for the years 1961, 1962, 1963, 1964, and 1965 for the low flow months of April, May, June, July, August, September, and October.

TABLE F-1. CORRELATION BETWEEN POTOMAC, BULL RUN, AND PATUXENT

	POTOMAC	BULL RUN	PATUXENT
POTOMAC		0.6442	0.6640
BULL RUN			0.6060
PATUXENT			

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The entries in the table are Pearson's correlation coefficients. Based on 40 degrees of freedom at the 0.05 level of significance the critical level is 0.3041. Therefore, we can see for the mean-low flow

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year there is a significant relationship between flow in the Potomac, the Bull Run, and Patuxent. Table F-2 is the same analysis with the low flow year of 1966 included.

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TABLE F-2. CORRELATION BETWEEN POTOMAC, BULL RUN, AND PATUXENT
(Low Flow of 1966 included)

	POTOMAC	BULL RUN	PATUXENT
POTOMAC		0.6226	0.6613
BULL RUN			0.6225
PATUXENT			

For the analysis with 47 degrees of freedom at the 0.05 level of significance the critical level is 0.2816. Therefore, we can say that the relationship including the low flow year is at least unchanged and perhaps even more significant than shown in Table F-1. Therefore, the admittedly limited analysis confirms that the situation depicted in Table 20 and Figure 31 is likely to occur during low flows.

SUSQUEHANNA AND POTOMAC BASIN ANALYSIS

If the Susquehanna is to provide a possible solution to the Potomac low flow problem, it is imperative that some limited examination be made of flows relationships between the Potomac and Deer Creek (a tributary to the Susquehanna) and the Patapsco. Table F-3 shows a correlation matrix for Potomac and Patapsco flows for 1961-1966 and for Potomac and Deer Creek flows for 1969 - 74, for the low flow months. The above elements are Pearson's correlation coefficients and the critical value at the 0.05 level of significance, for 40 degrees of freedom, is 0.3044. Therefore, we can tentatively conclude that although there is correlation between the Potomac and Patapsco, there is no correlation between the Potomac and Deer Creek. This raises the possibility to consider using water from the Susquehanna basin as an emergency supply.

TABLE F-3. CORRELATION BETWEEN POTOMAC, PATAPSCO, AND DEER CREEK

	POTOMAC	PATAPSCO	DEER CREEK
POTOMAC		0.9508	0.1162
PATAPSCO			0.0396
DEER CREEK			

SUMMARY STATISTICS

Table F-4 shows some of the relevant statistics for the Potomac, Bull Run, Patuxent, and Patapsco for the months of April, May, June, July, August, September, and October for the years 1961 - 1966. Figure F-1 is a plot of the average months' flows for 1969 - 1974, including the Deer Creek.

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TABLE F-4 AVERAGE MONTHLY FLOW (CFS) 1961 - 1966

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		Minimum	Maximum	Average	Std.Dev.
APRIL					
	Potomac	221,380	835,300	480,550	215,550
	Bull Run	957	9,267	5,740	3,179
	Patuxent	648	2,455	1,437	637
	Patapsco	1,376	5,104	2,727	1,407
MAY					
	Potomac	138,130	426,930	303,740	112,950
	Bull Run	431	5,412	2,353	1,843
	Patuxent	471	1,553	1,017	360
	Patapsco	1,001	3,269	1,886	784
JUNE					
	Potomac	70,370	191,400	127,910	58,363
	Bull Run	133	4,078	1,263	1,487
	Patuxent	386	990	627	246
	Patapsco	674	1,801	1,128	392
JULY					
	Potomac	32,743	88,890	62,686	21,436
	Bull Run	146	919	352	284
	Patuxent	129	791	357	230
	Patapsco	330	1,301	700	380
AUGUST					
	Potomac	28,797	71,100	45,015	14,388
	Bull Run	78	678	218	230
	Patuxent	87	2,676	655	995
	Patapsco	211	881	514	231
SEPTEMBER					
	Potomac	32,009	121,450	54,046	34,476
	Bull Run	82	7,892	1,579	3,112
	Patuxent	168	1,806	699	743
	Patapsco	269	1,728	629	549
OCTOBER					
	Potomac	30,840	180,190	75,367	54,075
	Bull Run	60	5,823	1,228	2,265
	Patuxent	188	752	349	206
	Patapsco	396	1,131	701	267

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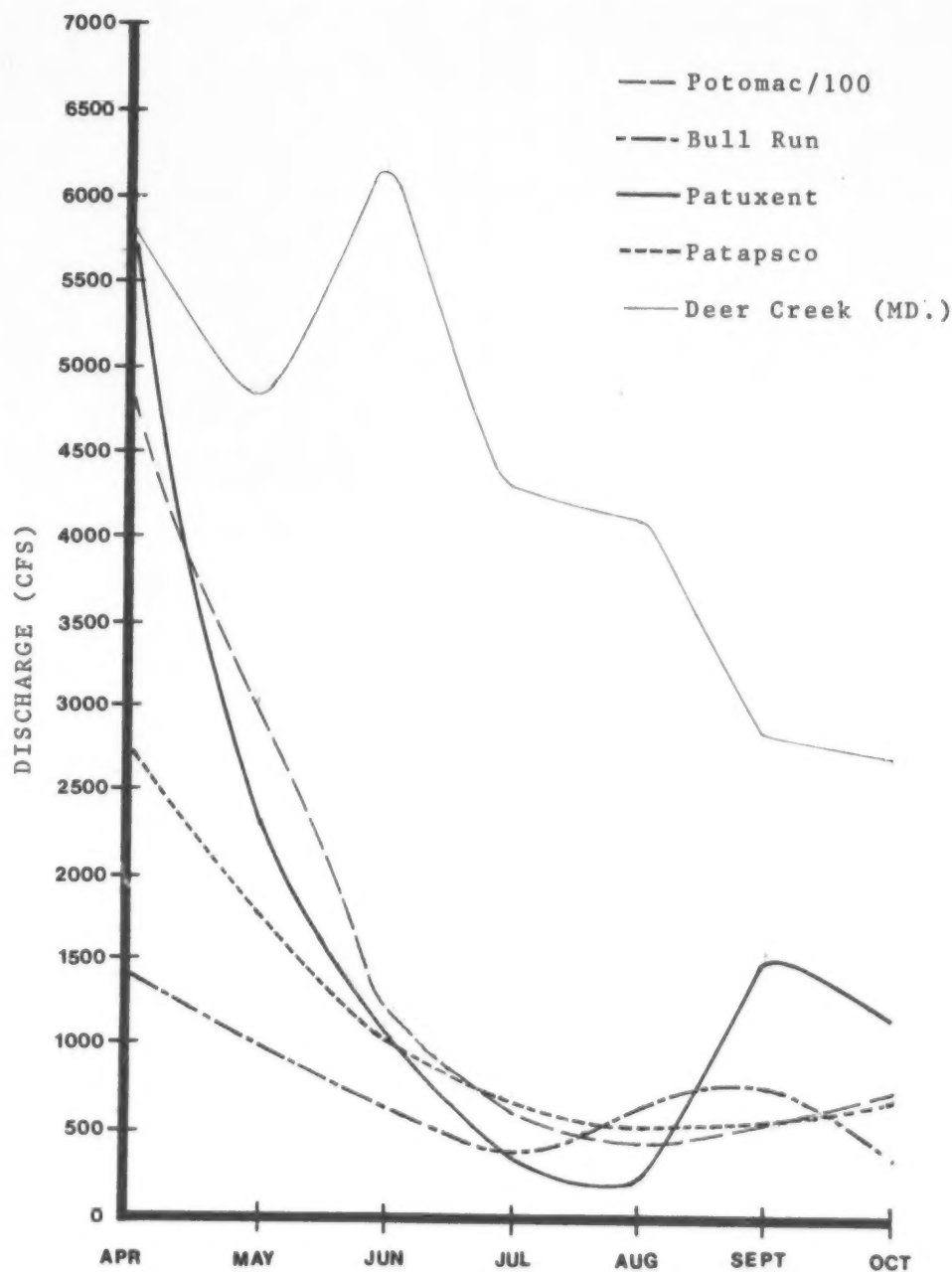


Figure F-1. Average Monthly Flows (1969-1974)

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APPENDIX G

COMPARATIVE COST ANALYSIS

A comparative cost analysis requires a careful development. The following assumptions were used for this analysis:

1. All costs are in 1976 dollars.
2. Only one cost category would be varied at a time, so that impacts could be examined individually.
3. Increased cost would be allocated equally to all water in the WMA, regardless of their source of supply.
4. Cost impacts would be limited to changes through 2030, since that period contained the most accepted population figures and since interconnects and RWW did not completely solve the deficit problems (as constraint in this study) through 2050.
5. The existing supplies will satisfy the WMA demand until the year 1999; therefore there will be no change in cost (in 1976 dollars) until that time. (Includes Bloomington and 2-day system storage.)
6. The cost impact will be the average cost per mil gal for water during the period 2000 - 2030.

LOW FLOR AUGMENTATION IMPACT

The first step in this analysis is shown in Table G-1 which is the calculation for determining the cost impact on the acquisition category of utility cost. The first group of columns show the cumulative cost (O&M and Capital) for the three river flow conditions (1930, 1932, 1966) for each alternative solution (reservoir, RWW, and interconnects). This cost started when the first facility became operational and was accumulated annually as facilities were added, through the year 2030. The costs were determined by the computer model discussed in Appendix D. The cumulative RPW column shows the projected cumulative RPW that the WMA would use between 2000 and 2030. The final group of columns is the cumulative cost divided by the cumulative RPW which gives the average cost (\$/mil gal) for each alternative, for each river flow condition. The rounded values from the 1930 flow conditions for Reservoir of \$12/mil gal, RWW of \$68/mil gal and Interconnects of \$58/mil gal were used in Table 34 of the main text and in the following tables to show cost impact.

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TABLE G-1. AVERAGE COST OF RPW (CUMULATIVE YEAR 2000 THROUGH 2030) FOR VARIOUS ALTERNATIVES

ALTERNATIVES	ALTERNATIVE CUMULATIVE COST MILLION DOLLARS			CUMULATIVE RPW * MG	AVERAGE COST PER ALTERNATIVE \$/MG		
	1930	1932	1966		1930	1932	1966
RESERVOIR	104.5	57.1	104.5	8,539,741	12.24	6.69	12.24
RWW	579.7	283.3	729.2	8,539,741	67.88	33.17	85.39
INTERCONNECTS	493.6	242.6	550.5	8,539,741	57.80	28.41	64.46

* TOTAL CUMULATIVE/RPW

1980-2030	10,363,455 (MG)
(-) 1980-1999	1,823,714
2000-2030	<u>8,539,741 (MG)</u>

TABLE G-1. AVERAGE COST OF RPW (CUMULATIVE YEAR 2000 THROUGH 2030) FOR VARIOUS ALTERNATIVES

ALTERNATIVES	ALTERNATIVE CUMULATIVE COST MILLION DOLLARS			CUMULATIVE RPW * MG	AVERAGE COST PER ALTERNATIVE \$/MG		
	1930	1932	1966		1930	1932	1966
RESERVOIR	104.5	57.1	104.5	8,539,741	12.24	6.69	12.24
RPW	579.7	283.3	729.2	8,539,741	67.88	33.17	85.39
INTERCONNECTS	493.6	242.6	550.5	8,539,741	57.80	28.41	64.46

* TOTAL CUMULATIVE/RPW

1980-2030	10,363,455 (MG)
(-) 1980-1999	1,823,714
2000-2030	8,539,741 (MG)

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Table G-2 shows the impact of each of the augmentation alternatives for the 1930 flow conditions of reservoir, RWW, and interconnects on each of the water utilities included in this study. By following the line which contains the name of each utility across the columns the present cost for producing water at that utility can be seen. These values, for each utility, can be found in Appendix E, on the last page of the each utility's computer printout. If the increased cost for acquiring the water to meet possible deficits (from Table G-1) is added to the present acquisition cost, the increased cost will reflect the impact. The cost shown below each of the present acquisition values identifies what the acquisition cost would increase to if the reservoir, RWW, or interconnect alternatives was chosen as a solution. For example, WSSC has a present acquisition cost of \$15/mil gal. If the reservoir alternative is selected, the acquisition cost will increase to an average of \$27/mil gal during the 2000 to 2030 time period. This will increase the total cost from \$566/mil gal to \$578/mil gal (shown under the TOTAL column), or 2.1 percent increase (last column). All utilities studied are included in Table G-2; however, this technique may not be applicable to all. For example, Leesburg presently uses ground water but is planning to use Potomac water in the future. This is a major change to their system and would, most likely, completely rearrange and change their cost, thus making these projections incorrect. FCWA is also planning an intake on the Potomac, but will continue to use their existing facilities. This change will also alter their cost to some degree beyond just acquiring additional source water.

The last group of costs on Table G-2 reflects a composite of all utilities studied. This composite was developed by dividing the summation of all utilities cost for each category by the summation of all of their RPW for the present year. This was accomplished to show the general impact on the area.

Table G-3 utilizes the composite utility cost from Table G-2 and identifies cost impact for the specific years of 2000, 2015, and 2030. In examining this Table it must be remembered that the specific use of a facility may be very low for a given year. For example, a RWW facility in a given year may have just been completed which solves a problem for 10 years into the future. For the first year of its operation, its annual depreciation along with all other costs are divided by the RPW for that year, thus giving a higher cost per mil gal then 10 years later when the RPW has significantly increased. Therefore, Table G-3 should be used with care.

Table G-4 estimates the annual cost impact on a home in the WMA which utilizes an average of 10,000 gal of water per month. This Table is for the same years as Table G-3 and the values should be considered in the same light.

Water Treatment Cost Impact

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A major concern for the future is the impact of the Safe Drinking Water Act on the cost of water supply. To illustrate the potential impact,

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TABLE G-2. WASHINGTON AREA LOW FLOW AUGMENTATION IMPACT

	SUPPORT SERVICES	ACQUISITION	TREAT- MENT	DISTRI- BUTION	INTEREST	TOTAL	PERCENT INCREASE
D.C. Water System	88	12	76	155	27	358	
Reservoir		24				370	3.4
RMW		80				426	19.0
Interconnects		70				416	16.2
*FALLS CHURCH	127	187	0	148	25	448	
Reservoir		199				500	2.5
RMW		255				556	13.9
Interconnects		245				546	11.9
*ARLINGTON	76	157				500	
Reservoir		169				512	2.4
RMW		225				568	13.6
Interconnects		215				558	11.6
WASHINGTON SUBURBAN SANITARY COMMISSION	43	15	122	249	136	566	
Reservoir		27				578	2.1
RMW		83				634	12.0
Interconnects		73				632	10.2
ROCKVILLE	131	53	140	225	70	619	
Reservoir		65				631	1.9
RMW		121				687	11.0
Interconnects		111				677	9.4
FAIRFAX COUNTY WATER AUTHORITY	118	34	61	127	230	570	
Reservoir		46				582	2.1
RMW		102				638	11.9
Interconnects		92				628	10.2
LEESBURG	126	150	35	459	140	910	
Reservoir		162				922	1.3
RMW		218				978	7.5
Interconnects		208				968	6.4
COMPOSITE	80	32	82	184	97	475	
WATER COST FOR ABOVE		92				487	2.5
Reservoir		148				543	14.3
RMW		138				533	12.2
Interconnects							

NOTE: ACQUISITION COST INCREASED BY \$12 WHICH IS COST (\$/mil gal) FOR WATER SUPPLY ALTERNATIVES BY RESERVOIRS.
ACQUISITION COST INCREASED BY \$68 WHICH IS COST (\$/mil gal) FOR WATER SUPPLY ALTERNATIVES BY RMW.
ACQUISITION COST INCREASED BY \$58 WHICH IS COST (\$/mil gal) FOR WATER SUPPLY ALTERNATIVES BY INTERCONNECTS.
VALUES ARE ROUNDED AFTER ADDITION.

* Acquires source water from Washington Aqueduct.

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TABLE G-3. COMPOSIT 1976 WATER SUPPLY COST WITH PROJECTED AVERAGE COST IMPACT
FOR DESIGNATED YEARS USING 1930 RIVER FLOW CONDITIONS WITH NORMAL
DEMAND RPW (\$/MG)

YEAR	SUPPORT SERVICES	ACQUISITION	TREATMENT	DISTRIBUTION	INTEREST	TOTAL	PERCENT INCREASE
1976	80	32	82	184	97	475	
	<u>RESERVOIRS</u>						
2000		47				490	3.1
2015		45				488	2.7
2030		44				487	2.5
	<u>RPW</u>						
2000		69				512	7.8
2015		113				556	17.1
2030		137				580	22.1
	<u>INTERCONNECTS</u>						
2000		85				528	11.2
2015		81				524	10.3
2030		101				544	14.5

TABLE G-4. HOME CONSUMPTION COST INCREASE USING VARIOUS
ALTERNATIVES FOR DESIGNATED YEARS*

	<u>1976-2000</u>	<u>2000</u>	<u>2015</u>	<u>2030</u>
	\$ /YEAR	\$ /YEAR	\$ /YEAR	\$ /YEAR
RESERVOIRS	(NO CHANGE)	1.86	1.59	1.40
RWW	(NO CHANGE)	4.46	9.67	12.63
INTERCONNECTS	(NO CHANGE)	6.40	5.90	9.53

* (SUPPLY = 1930 RIVER FLOW CONDITION PLUS BLOOMINGTON RESERVOIR)
ASSUMING 120,000 GAL/YR AVERAGE HOME CONSUMPTION

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an incremental cost table was developed. Table G-5 contains the incremental costs for various disinfection alternatives and for granular activated carbon assuming the affected utility already has chlorination in place. Since needed raw water quality information is not available at this time, the treatment cost are general and are included to help define the range of possible costs incurred. As more information is obtained about the actual quality of the water, as it relates to the new regulations, more accurate treatment cost estimates can be made.

TABLE G-5. INCREMENTAL COSTS FOR TECHNOLOGY (\$/mil gal)

TECHNOLOGY	SYSTEM SIZE (MGD)				
	1	5	10	100	150
Chlorine Dioxide	17	4.2	2.4	1.1	1.0
Ozone	29.2	12.9	10.4	5.3	4.4
GAC	443	220	179	107	101

The values in Table G-5 are applied to the total water supply cost in the same manner as to acquisition cost, i.e. they are added to the existing treatment cost. The impact of treatment cost is shown in Table G-6 (which also shows acquisition cost impact). Using WSSC as an example, present treatment cost is \$122/mil gal. If ozone is utilized, the treatment cost would increase to \$127/mil gal (column 2) and the total water supply cost would increase from \$566/mil gal (column 3) to \$571/mil gal (column 4) or 0.9 percent (column 5). The remaining columns indicate the impact where the new treatment processes are added to the alternative for solving the low flow problem.

Tables G-7 and G-8 are the same presentation of data as Table G-6 but for the Potomac River flow for 1932 and 1966 respectively. The cost of acquiring the water changes for each of the years due to the different flow levels, but the treatment impact on a \$/mil gal basis remains the same since it is assumed that the quality of the water remains the same.

These cost are for illustrative purposes only. To determine the actual cost in a specific utility would require site specific water quality and design studies. Such studies were not a part of this effort.

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TABLE G-6. WASHINGTON AREA UTILITY COST SUMMARY (\$/mil gal)
1930 RIVER FLOW CONDITIONS

	INCREMENTAL		TOTAL					
	Present	Projected	Present	Projected	Percent Increase	New Acq. + Chlorine Dioxide	Percent Increase + Ozone	New Acq. + GAC
K38C								
			566					
ACQUISITION	15	27						
Reservoir								
RW		83						
Interconnects		73						
TREATMENT	122	173						
Chlorine Dioxide								
Ozone		127						
GAC		226						
D.C. WATER SYSTEM								
			358					
ACQUISITION	12	24						
Reservoir		80						
RW		70						
Interconnects								
TREATMENT	76	77						
Chlorine Dioxide								
Ozone		80						
GAC		177						
FAIRFAX COUNTY								
			570					
ACQUISITION	34	46						
Reservoir		102						
RW		92						
Interconnects								
TREATMENT	61	63						
Chlorine Dioxide		69						
Ozone		205						
GAC								
ROCKVILLE								
			619					
ACQUISITION	53	65						
Reservoir		121						
RW		111						
Interconnects								
TREATMENT	140	144						
Chlorine Dioxide		153						
Ozone		360						
GAC								

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TABLE G-7. WASHINGTON AREA UTILITY COST SUMMARY (\$/mil gal)
1932 RIVER FLOW CONDITIONS

	INCREMENTAL		TOTAL				
	Present	Projected	Present	Projected	Percent Increase	New Acq. + Chlorine Dioxide	Percent Increase + Ozone
WSSC							
ACQUISITION	15						
Reservoir		22		573	1.2	574	1.4
RW		48		599	5.8	600	6.0
Interconnects		43		594	4.9	595	5.1
TREATMENT	122						
Chlorine Dioxide		123		567	0.2		
Ozone		127		571	0.9		
GAC		226		670	18.4		
D.C. WATER SYSTEM							
ACQUISITION	12						
Reservoir		19		365	2.0	366	2.2
RW		45		391	9.2	392	9.5
Interconnects		40		386	7.8	387	8.1
TREATMENT	76						
Chlorine Dioxide		77		359	0.3		
Ozone		80		362	1.1		
GAC		177		459	28.2		
FAIRFAX COUNTY							
ACQUISITION	34						
Reservoir		41		577	1.2	579	1.6
RW		67		603	5.8	605	6.1
Interconnects		62		598	4.9	600	5.3
TREATMENT	61						
Chlorine Dioxide		63		572	0.4		
Ozone		69		578	1.4		
GAC		205		714	25.3		
ROCKVILLE							
ACQUISITION	53						
Reservoir		60		626	1.1	630	1.8
RW		86		632	5.3	636	6.0
Interconnects		81		647	4.5	651	5.2
TREATMENT	140						
Chlorine Dioxide		144		623	0.6		
Ozone		153		632	2.1		
GAC		360		839	35.5		

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TABLE C-8. WASHINGTON AREA UTILITY COST SUMMARY (\$/mil gal)
1966 RIVER FLOW CONDITIONS

	INCREMENTAL		TOTAL			
	Present	Projected	Present	Projected	New Acq. + Chlorine Increase	Percent Increase + Ozone
WSRC						
ACQUISITION	15					
Reservoir	27		578	2.1	579	3.0
RMW	100		651	15.0	652	15.9
Interconnects	79		630	11.3	631	12.2
TREATMENT	122					
Chlorine Dioxide	123		587	0.2		
Ozone	127		571	0.9		
GAC	226		670	18.4		
D.C. WATER SYSTEM			358			
ACQUISITION	12					
Reservoir	24		370	3.4	371	4.5
RMW	97		443	23.7	444	24.9
Interconnects	76		422	17.9	423	19.0
TREATMENT	76					
Chlorine Dioxide	77		359	0.3		
Ozone	80		362	1.1		
GAC	177		459	28.2		
FAIRFAX COUNTY			570			
ACQUISITION	34					
Reservoir	46		582	2.1	584	3.5
RMW	119		655	14.9	657	16.3
Interconnects	98		634	11.2	636	12.6
TREATMENT	61					
Chlorine Dioxide	63		572	0.4		
Ozone	69		578	1.4		
GAC	205		714	25.3		
ROCKVILLE			619			
ACQUISITION	53					
Reservoir	65		631	1.9	635	4.0
RMW	138		704	13.7	708	15.8
Interconnects	117		683	10.3	687	12.4
TREATMENT	140					
Chlorine Dioxide	144		623	0.6		
Ozone	153		632	2.1		
GAC	360		839	35.5		

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